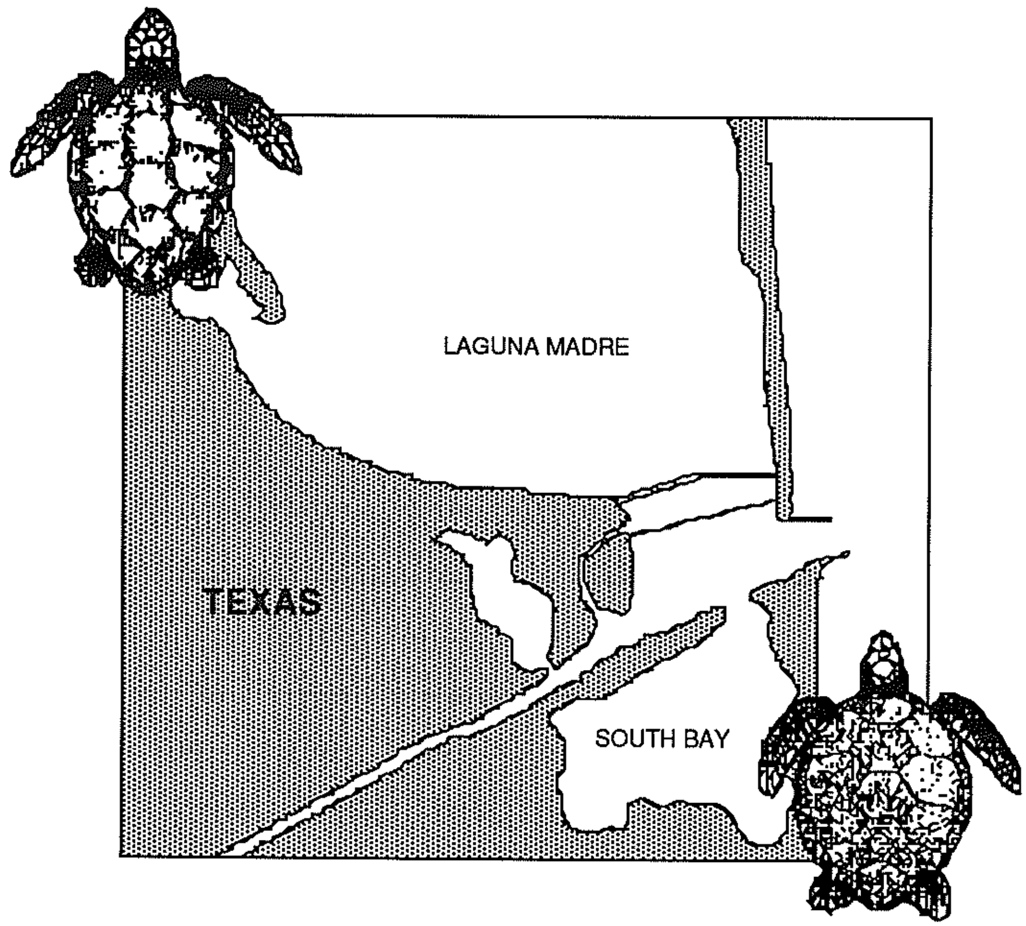
TRACKING OF GREEN (*Chelonia mydas*) AND LOGGERHEAD (*Caretta caretta*) SEA TURTLES USING RADIO AND SONIC TELEMETRY AT SOUTH PADRE ISLAND, TEXAS



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National Marine Fisheries Service
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Tracking of green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles using radio and sonic telemetry at South Padre Island, Texas.

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BY

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INTRODUCTION

Until recently, virtually no research had been conducted on sea turtle populations inhabiting the lower Laguna Madre in south Texas. Historically, this area was an important habitat for sea turtles, especially the green sea turtle (*Chelonia mydas*). In 1890 when the commercial sea turtle fishery in Texas was at its peak, the lower Laguna Madre accounted for 22,000 kg of sea turtles, 1/10 of the State's total sea turtle landings. By 1900 sea turtles in this region were scarce and the fishery collapsed (Doughty 1984). Over the years some research has been devoted to studying the nesting activity of sea turtles and the documentation of sea turtles stranded on south Texas beaches (Francis 1978; Rabalais and Rabalais 1980). These studies led to the establishment of the Sea Turtle Stranding and Salvage Network (STSSN) in 1980. Moreover, Shaver (1990a) summarized hypothermic stunning ("cold stunning") of sea turtles that occurred in coastal inshore waters of central and south Texas in 1971, 1979, 1983 and 1989. A total of 59 cold stunned sea turtles, 58 greens and one loggerhead (*Caretta caretta*), were found in the Laguna Madre south of Port Mansfield. Forty five of these sea turtles were found during a severe cold spell in 1989.

In 1989, three separate studies concerning sea turtles in the Laguna Madre were conducted by the National Park Service (NPS) and the National Marine Fisheries Service (NMFS). NPS conducted a mark/recapture study in the upper Laguna Madre from Corpus Christi to Port Mansfield (Shaver 1990b) and NMFS, using radio and sonic transmitters, recorded the movements and surfacing and submerging behavior of a single green turtle in the lower Laguna Madre south of Port Mansfield (Manzella et al. 1990). These studies, along with NMFS observations of sea turtles around the jetties at Port Mansfield and Brazos Santiago Pass, led to the development of a third project, a sea turtle sighting campaign. Aimed at collecting information from the general public, signs were posted at jettied passes along the Texas coast (Sabine Pass, Bolivar Pass, San Luis Pass, Freeport Jetties, Aransas Pass, Fish Pass on Mustang Island, Brazos Santiago Pass). As a result, numerous sea turtle sightings were reported (Williams and Manzella 1990; Williams and Manzella, In press). Although identification of species by the general public could not be verified, observations from NMFS and NPS personnel suggested that most of the sightings at jetties were of small green sea turtles.

From this information we hypothesized that jettied passes and associated dredged channels could be an important artificial habitat used by young sea turtles. Unfortunately, the situation is potentially life threatening for sea turtles since the major passes and ship channels along the Texas coast are routinely dredged. It is well known that dredging, especially using a hopper dredge, can be fatal to sea turtles (Dickerson and Nelson 1990). Due to mounting concern by the Galveston and New Orleans Districts of the U. S. Army Corp of Engineers, a plan to study sea turtle behavior near dredged channels was funded in 1990.

The objectives of the study were 1) to determine sea turtle behavior and movement in the lower Laguna Madre and Brazos Santiago Pass (BSP) area, near the jetties, 2) to characterize these habitats and available food items (refer to the accompanying report by Landry et al. 1992), and 3) to refine methodology for local movement and habitat characterization studies, so it may be used in similar areas.

METHODS

Capture of Sea Turtles

Sea turtles were captured by setting entanglement nets perpendicular to prevailing water currents near the jetties or in seagrass beds adjacent to channels. These methods are described in detail in the accompanying report by Landry et al. (1992).

Study Area

The study was conducted in the lower Laguna Madre near Port Isabel and South Padre Island, Texas. The area can be divided into three distinct regions: 1) the bay north of the Queen Isabella Causeway, 2) the bay south of the Queen Isabella Causeway and landward of South Padre and Brazos Islands and 3) the Brazos Santiago Pass area (Fig. 1). The bay north of the causeway is very shallow, less than 2 m deep in most areas, with a hard sand bottom that supports beds of *Thalassia testudinum* (turtle grass), *Syringodium filiforme* (manatee grass) and *Halodule wrightii* (shoal grass). Quammen and Onuf, (1991) described the distribution of seagrass beds in the lower Laguna Madre and conducted extensive studies on changes in salinity, increased siltation rates and loss of seagrass beds in this area as well. Commercial fishing is prohibited here, however this habitat does support a major recreational fishery. The Intracoastal Waterway (ICWW) generally bisects the region from south to north. North of the causeway, a channel leading to the Port Isabel small boat basin, connects to the western edge of the

ICWW. To the east of the ICWW, a privately maintained channel runs along the base of the causeway to South Padre Island. These channels are the deepest areas in the lower Laguna Madre having a mean water depth of about 4 m. The small boat basin channel and the ICWW are maintained annually using a pipeline suction dredge.

The area south of the Queen Isabella Causeway (Region 2) is also shallow and characterized by mud and seagrass flats. This region is divided by the "old causeway" which once connected Port Isabel to South Padre Island. Currently there is a break in the middle of the causeway to allow passage of boats. The Brownsville Ship Channel (BSC) runs east/west and is located on the southern end of region 2. It is routinely maintained with a hopper dredge and has a water depth of about 12 m. South Bay, mostly less than 0.6 m in depth, extends to the south from the BSC. The entrance to South Bay is not dredged and has a depth of 2-3 m. The BSC is routinely fished by bait shrimpers and South Bay is a popular site for recreational fishermen.

Region 3, the Brazos Santiago Pass area, includes Dolphin and Barracuda Coves located immediately south of South Padre Island and immediately north of Brazos Island respectively, out to and in the vicinity of the north and south jetties. Jetties are 92 m apart and extend 1.5 km into the Gulf of Mexico. Together with Mansfield Pass, this is the only communication of water between the Gulf of Mexico and the lower Laguna Madre. The coves and jetties are popular sites for recreational fishing.

Tagging

Sea turtles were held from 24-72 hours following their capture for observation, attachment of the transmitters and flipper tags and the collection of fecal samples. Radio transmitters (164.0-165.9 Mhz) manufactured by Telonics, Inc. of Mesa, Arizona, were attached to the second neural scute of each sea turtle using epoxy and then secured with fiberglass cloth and resin. Sonic transmitters (32-40 Khz) were manufactured by Sonotronics of Tuscon, Arizona and Custom Telemetry of Athens, Georgia. The transmitters were attached to the posterior marginal scutes using nuts and bolts. Frequencies of radio and sonic transmitters are given in Table 1.

All sea turtles were tagged on the right and left front flippers using Hasco type, style 681 inconel tags manufactured by National Band and Tag Co. of Newport, Kentucky. Straight line and curved carapace lengths and widths were recorded for all sea turtles. Once tagged and fitted with transmitters, the sea turtles were released at their capture site. Numbers of flipper tags are listed in Table 1.

Tracking

Radio transmitters were monitored using a Telonics TR2/TS1 receiver/scanner connected to a directional 5-element Yagi antenna and a 21X Datalogger manufactured by Campbell Scientific, Inc., Logan, Utah. Reception of radio signals varied between 10-16 km. Sonic transmitters were monitored using a directional hydrophone manufactured by Dukane Corporation of St. Charles, Illinois. Receiving ranges for the sonic transmitters varied between 0.6 and 1.1 km.

An automated datalogger and receiving antenna, set up at the U.S. Coast Guard Station, South Padre Island, TX, remotely recorded the surfacing events of all tagged sea turtles, twenty-four hours a day. The system was calibrated and tested in the spring of 1991 and test data were found to be comparable with information gathered by field personnel. During the present study, reception ranges for the Datalogger were set to the values tested earlier in the year.

One or more sea turtles were tracked during a 12 hour period each day from 28 June through 22 August. Two additional trips, each three days in duration, were completed in September to gain more information on sea turtle locations. Frequencies of radio transmitters were monitored and the time interval that each sea turtle/transmitter was on the surface was recorded by field personnel. Surface and submerged times were calculated for each sea turtle. Comparisons between surface and submerged times between day (0630-2029) and night (2030-0629) were conducted using a Students t-test with alpha = 0.05. Surface times are slightly inflated due to the fact that sea turtles can swim near the surface with the 40-cm antenna on the radio tag penetrating the air-water interface, while they are still submerged. For the same reason, submerged times are slightly underestimated. Geographic location of a sea turtle was noted if it was visually sighted or if its position could be pinpointed with the sonic receiver. Most of the data were collected during daylight hours, however, some tracking was accomplished at night. Data on opportunistic sightings of tagged sea turtles were also available from Texas A&M University (TAMU) researchers from June through November, 1991.

In the bay, sea turtle locations were recorded using a portable APELCO DXL 6300 Loran C. An alternate method of recording a sea turtle position was implemented at the jetties. Numbered markers were placed at 46-m intervals shoreward from the seaward tip of the jetties. The location of a sea turtle was determined by its position with respect to the markers and its perpendicular distance from the jetties.

Environmental Data

Water temperature and salinity were recorded every 30 minutes using a submersible DataSonde III manufactured by Hydrolab Corporation of Austin, Texas. The DataSonde III was deployed in 1-2 m of water at a tide gauge located in Dolphin Cove near the north jetty (28 June to 11 July and 17 July to 14 August 1991) and in 3 m of water near a small boat basin channel adjacent to the ICWW just north of the Queen Isabella Causeway (13 to 17 July 1991).

Habitat Characterization

Twenty-eight sampling stations were characterized in the lower Laguna Madre; 16 stations in Region 1, 5 stations in Region 2 and 7 stations in Region 3 (Fig. 1). Hydrological monitoring, sediment analyses, vegetation characterization and trawl surveys were conducted at each station. Landry et al. (1992) provides specific information on procedures used in habitat characterization.

RESULTS

Capture and Tagging of Sea Turtles

Four green sea turtles (Chelonia mydas) and one loggerhead sea turtle (Caretta caretta) were fitted with radio and sonic transmitters and released at their capture sites near South Padre Island, TX. Locations, dates of capture and release, morphometric measurements, tag numbers and radio/sonic transmitter frequencies of the sea turtles are given in Table 1.

Sea Turtle Movement Patterns

A loggerhead sea turtle (L1), captured in Region 1 on 26 June 1991 near a submerged bank on the west side of the ICWW, was tracked daily from 28 June to 15 July and intermittently through 20 August 1991 (Table 1). One hundred seventy-two tracking hours were logged, most of which occurred between 0600 and 1800 hours (Fig. 2a). Sightings of L1 were mostly in the ICWW during the morning and early afternoon (0700-1400 hours) and in the shallow areas adjacent to the ICWW in the early morning (0300-0700 hours) and late afternoon (1400-1800 hours). On two occasions L1 traveled 5.6 km to the north in the ICWW near marker #117 during the morning and midday, and returned to the south near markers #139 and #141 by the following morning. Figures 3 and 4 summarize L1's locations during daylight hours and nighttime hours. Last contact of L1 was on 24 September 1991. Based only on the reception of radio signals, L1 was believed to be in the southern portion of Region 1 .

Four green sea turtles (G1-G4) were captured from 15 July to 4 August 1991 (Table 1). G1, captured in Region 3 on 15 July 1991, on the south side of the north jetty, was tracked intermittently from 16 July through 18 August 1991 (Table 1). Ninety-nine tracking hours were logged, most of which occurred between 0400 and 1500 hours (Fig. 5a). Following its release G1 immediately swam across the BSC to the north side of the south jetty, through the BSP and around to the south side of the south jetty. Over the next 4 days, G1 stayed close to the south side of the south jetty, but, on one occasion the sea turtle spent time on the north side of the south jetty. On 21 July, G1 was sighted at the north side of the north jetty, where it remained almost entirely for the duration of the study. Short excursions were made by the sea turtle to the south side of the north jetty when sea conditions were very calm (< 0.3 m). During the daytime G1 would move back and forth along the jetty from 0.3-9.1 m of the jetty rocks (Fig. 6). Little or no sea turtle movement was detected during nighttime observations (Fig. 7). G1 was last sighted on 26 October 1991 on the north side of the north jetty.

A second green sea turtle (G2), captured in Region 2 on 26 July 1991 in shallow water adjacent to Mexiquita Flats (seagrass beds on the north side of the BSC) was tracked intermittently from 28 July to 22 August 1991. Fifty-nine hours of tracking were logged, most of which occurred between 0400 and 1600 hours (Fig. 8a). Following its release, G2 swam across the BSC into the entrance of South Bay and remained mostly in the eastern portion of this area. G2 was located inside South Bay on two occasions and also spent time in the BSC directly in front of the South Bay entrance (Fig. 9). On the three nights that G2 was tracked, between 0300-0600 hours, the sea turtle was located just inside the entrance to South Bay (Fig. 10). Last contact of G2 was made via sonic receiver on 24 September 1991. G2 was believed to be in the BSC just outside the entrance to South Bay.

The third green sea turtle (G3), captured in Region 2 on 1 August 1991, adjacent to Mexiquita Flats, was tracked intermittently from 2 to 22 August 1991 (Table 1). Forty-three daytime tracking hours were logged between the hours of 0630-1600 (Fig. 11a). G3 remained mostly on the north side of the BSC and in the shallow area adjacent to the north side of the channel (Fig. 12). On occasion this sea turtle was tracked to the south side of the BSC. G3's range of movement was along the BSC between channel markers #9 and #27, a distance of approximately 2.6 km. G3 spent very little time at the surface and showed signs of high activity similar to the other sea turtles. Last contact with G3 was made in Region 2 by sonic receiver on 24 September 1991 (Fig. 12).

A fourth green sea turtle (G4), also captured in Region 2 on 1 August 1991 near Mexiquita Flats, was tracked intermittently from 4 to 20 August 1991 (Table 1). Thirty-eight daytime tracking hours were logged between 0630-1700 hours (Fig. 13a). G4 showed the most movement of all the tagged sea turtles (Fig. 14). Immediately following its release, G4 moved in an easterly direction in the BSC until it reached the Gulf of Mexico. It proceeded out the BSP and northward. Sea state precluded following G4 offshore; however, this sea turtle was monitored by sonic telemetry simultaneously while monitoring G1 at the jetties. By late afternoon G4 had reversed its direction of movement, crossed the mouth of the BSP and was south of the jetties. G4 re-entered the BSC during the evening and remained near channel marker #9 for two days before moving north of the Queen Isabella Causeway. The sea turtle moved into the ICWW approximately 7.4 km north of the Causeway and 10.7 km from channel marker #9. On 8 August, G4 was located on seagrass beds west of the ICWW and in the ICWW near a private channel that parallels the Queen Isabella Causeway on 15 August. The last sighting of G4 occurred on 16 August 1991, in the area just north of the Queen Isabella Causeway, near the private channel. The sonic transmitter became dislodged and was recovered in this vicinity a few days later. Weak radio signals were received over these last days, but no direction toward G4 was obtainable.

Submergence Behavior

The overall mean submergence times (2.4 - 4.3 minutes) of these sea turtles were much lower than expected (Table 2). A more detailed breakdown of the submergence times during the day revealed that 89% to 99% of sea turtle dives were less than 10 minutes in duration and that 17% to 56% of the total number of dives were less than 1 minute (Fig. 15). During the day it was uncommon for sea turtles to submerge for periods greater than 10 minutes in duration. Submergence ranging from 5 to 10 minutes in duration was generally followed by several short submergence periods of less than 1 minute in duration.

Submergence information during the night was only collected for 3 sea turtles. Although sample size did not allow for between-species analyses, it appeared that some behavioral differences may occur between loggerhead and green sea turtles with respect to submergence durations at night. Periods of submergence of less than 10 minutes in duration accounted for 42%-74% (greens) and 78% (loggerheads) of the total number of dives (Fig. 16). Submergence patterns of the loggerhead sea turtle did not vary much at night compared to its daytime activity. Green sea turtles, however, showed a marked difference in their submergence patterns. There was an increase of 21% to 58% in the number of times the submergence of a sea turtle lasted for more than 10 minutes. Twenty-six to fifty-eight percent of dives at night by green sea turtles are greater than 10 minutes in duration. Little or no movement by the sea turtles was observed during this diving activity. This may be indicative of resting behavior. Twenty-one percent of the dives at night by the loggerhead were greater than 10 minutes. The loggerhead did not remain in a localized area during longer periods of submergence. It was more active at night than the green sea turtles.

The mean surface and submergence times for L1 during the day were 3.9 seconds and 4.3 minutes respectively (Fig. 2b). A change in this pattern occurred during the night. Mean surface (12.6 seconds) and submergence (6.5 minutes) times were significantly higher at night compared to the daytime (Fig. 2b); i.e., fewer number of dives, with increased duration and surface times were made by L1 at night compared to its daytime behavior. These behavioral changes corresponded closely to dusk and dawn. Submergence periods from 20-55 minutes with up to 3 minute surface times at night may correspond to rest periods. This behavior, although more common at night, was also observed during the day. While daytime observations reflected some movement, usually little or no movement was noted at night.

Changes in the mean length of surface and submergence times between day and night periods were more pronounced for G1 than for L1 (Fig. 5b). During the daytime, periods of high activity (swimming, foraging) were associated with mean surface and submergence times of 30.0 seconds and 3.5 minutes respectively. Periods of low activity (resting), associated with higher mean surface (74.4 seconds) and submergence (25.6 minutes) times, occurred during nighttime hours. Nighttime surface and submergence times were significantly higher than the corresponding day time values.

Changes in the mean length of surface and submergence times between day and night periods for G2 were similar to that of G1 (Fig. 8b). Periods of high activity (swimming, foraging), associated with very short mean surface (2.4 seconds) and submergence (2.6 minutes) times, occurred during daytime.

Periods of low activity (resting) were associated with longer mean surface (50.0 seconds) and submergence (4.0 minutes) times and occurred during nighttime hours. Surfacing and submerging behavior were similar to that exhibited by L1 and G1 at dawn and throughout the daytime hours. No data were collected at dusk. Collection of data for G2 was performed with little success at night. This sea turtle frequented areas in South Bay less than 0.4 m depth. As a result, the transmitter antenna was usually sticking out of the water and field personnel could not tell if the sea turtle was on the surface or under the water.

Mean surface and submergence times for G3 were 2.3 seconds and 2.4 minutes respectively. G3 remained submerged for periods ranging from 15 to 20 minutes in the middle of the BSC. No nighttime submergence behavior was recorded for G3.

G4 had mean surface and submergence times of 2.2 seconds and 3.6 minutes respectively. No nighttime submergence behavior was recorded for this sea turtle.

Environmental Data

Water temperatures collected every 30 minutes for 38 days at the tide gauge near the north jetty at the BSC and for 4.5 days in the lower Laguna Madre just north of the Queen Isabella Causeway ranged from 23.9-30.4 C and 25.4-31.3 C respectively (Fig. 17). Salinity data collected for 14 days at the north jetty ranged from 33.3-37.6 ppt (Fig. 18). Values for water temperature and salinity were within ranges recorded during the previous 10 years. Gaps in the data were due to equipment failure and eventual theft of the equipment. Landry et al. (1992) present additional temperature and salinity data for these time periods.

Habitat Characterization

Three habitats characterized during this study were 1) seagrass beds, 2) channels including the ICWW and 3) the jetties. Seagrass beds, by far the most expansive habitat of the lower Laguna Madre, were composed mainly of *Thalassia testudinum* and *Syringodium filiforme* while seagrass beds in South Bay and along the BSC in Mexiquita Flats were almost totally dominated by *Syringodium filiforme*. Portunid crabs and several species of grass shrimp and hermit crabs, present in both areas, were more numerous in the seagrass beds of the lower Laguna Madre than in South Bay or Mexiquita Flats. Although not vegetated, channels in the lower Laguna Madre harbored large populations of portunid crabs, shrimp, fish and squid. These invertebrate species were also present in the BSC and the BSP, but in much lower densities. The jetty habitat extends from the intertidal zone on the rocks, out 25 m to an area of scattered boulders approximately 8 m in depth. The jetty and adjacent rocky areas offer refuge for sea turtles and substrate for epifloral and epifaunal food sources. Barnacles (*Balanus sp.*), 3 algal species (*Ulva fasciata*, *Podina vickersiae*, and *Bryocladia thysigera*), and sea urchins (*Arbacia punctulata*) were the most abundant organisms at the jetties. Detailed descriptions and listings of all flora and fauna found at the seagrass bed, channel and jetty habitats are provided by

Landry et al. (1992).

Habitat Preferences

The loggerhead sea turtle spent approximately 50 percent of its time in each of the channel and seagrass bed habitats north of the Queen Isabella Causeway. These areas, abundant in several food items (listed above), were probably used as foraging grounds by L1. Channels may also be used as thoroughfares for rapid travel between areas in the lower Laguna Madre and between inshore and offshore habitats

G1 captured and released at the jetties remained there during the entire 56 day tracking period. It was seen there after 103 days by TAMU. Habitat fidelity may be due to abundance of algal food sources and protective cover provided by jetty rocks. Three additional green sea turtles were captured at Mexiquita Flats. G2 utilized South Bay, its entrance channel and adjacent seagrass beds almost 100 percent of the time. On occasion, G2 made short excursions into the BSC. G3 frequented the BSC and adjacent seagrass beds on both the north and south sides. Results of tracking effort showed that G3 spent approximately 80 percent of its time on the north side of the BSC. G4, the largest green sea turtle, spent time in the BSC (50%), ICWW (10%), seagrass beds (30%) north of the Queen Isabella Causeway, and offshore (10%) of South Padre Island. All of these green sea turtles were in habitats abundant in food items or close to habitats with food sources. It is estimated that these sea turtles spent 40 percent of their time associated with the channel habitat and the remaining 60 percent with seagrass bed habitats.

Other Sea Turtle Sightings

One hundred six sea turtles, without radio transmitters, were observed in or adjacent to dredged channels from 28 June - 24 September 1991; 95 greens, 3 loggerheads and 8 unidentified. An additional 42 green sea turtles were documented in these areas from 25 October through 12 December by TAMU personnel. Sea turtles were seen in all 3 Regions of the lower Laguna Madre described in the methods, on 40 of 89 days during the study (Fig. 19). However, loggerheads were seen only in Region 1.

More sea turtles were sighted at the jetty habitat than at channel and seagrass bed habitats combined (Fig 19). It was noted that green sea turtles that frequent the jetty habitat were smaller than green sea turtles seen elsewhere. Six green sea turtles, < 40 cm in straight carapace length, were captured by Landry et al. (1992) at the jetties. Twelve additional green sea turtles, > 40 cm in length were captured by TAMU near seagrass beds in the lower Laguna Madre. Turtle grass, a dominant floral species in this area, was the main component of fecal samples of sea turtles collected in these areas. Alternately, algae growing on the jetties were the main fecal components of the smaller sea turtles captured there. If habitat preference is being exhibited by these sea turtles it may be based on changes in sea turtle vegetal feeding preferences.

DISCUSSION

Habitat Utilization

The lower Laguna Madre is composed of two distinct habitat types: seagrass beds and channels including the ICWW. Jetty habitats link inshore and offshore areas. In our study area, seagrass beds were the most extensive habitat, followed by the channels and jetties. Sea turtles were not distributed equally over these areas or in relation to the extent of each habitat type. Between 28 June and 24 September, 82 sea turtles were seen at the jetties and 24 sea turtles in or near channels. Only 38 percent of the tracking and observation effort was spent at the jetty habitat. This suggests that jetties provide a high quality habitat for juvenile green sea turtles and that juvenile sea turtles may congregate there due to ample food and cover. G1 slept and foraged at the jetty habitat and did not leave the area for the duration of the study which reinforces the hypothesis that the jetty environment is attractive to sea turtles.

Turtle grass or algae were found in the fecal pellets of all green sea turtles collected during this study (Landry et al. 1992). Turtle grass was prevalent in the feces of sea turtles captured at Mexiquita Flats and algae dominated the feces of sea turtles taken at the jetties. Fourteen additional sea turtles captured by Landry et al. (1992) exhibited similar fecal contents.

Sightings and captures of sea turtles suggest that smaller sea turtles (< 40 cm straight carapace length) frequent the jetty habitat and those larger than 40 cm use the channels and seagrass beds within the lower Laguna Madre.

These sea turtle distributions may be due to changes in feeding preferences. Turtle grass was the main component of fecal samples taken from the larger green sea turtles that frequented the lower Laguna Madre (Landry et al. 1992). Alternately, algae conspicuous at the jetties were the main fecal components of smaller sea turtles. The importance of habitats to sea turtles may vary with changes in feeding preferences. Data are limited at this time and more information needs to be collected to clarify this matter.

Home Range

Four of the 5 sea turtles exhibited what could be interpreted as home range behavior, i.e., they remained for the most part within areas from 0.6-3.9 sq km. Feeding preferences may account for the limited movement of the sea turtles tracked in this study. The limited excursions of G1 have already been discussed. The loggerhead sea turtle was always in close proximity to the ICWW and adjacent seagrass beds. These habitats have high concentrations of food items, such as crabs and small fish. G2 and G3, had the smallest home ranges and were almost always in or near seagrass beds. All of the tracked green sea turtles were in habitats abundant in food items (algae or sea grass) or close to habitats with food sources.

Submerged Behavior

At least two types of submerged behavior of the sea turtles were noted. Periods of high activity (submergence of less than 20 minutes), possibly foraging, occurred during the daytime for both green and loggerhead sea turtles. It was hypothesized that the loggerhead sea turtle spent some time foraging at night due time periods of moderate activity. Resting behavior (submergence greater than 20 minutes), generally observed at night, also occurred minimally during the day for both species of sea turtles. Daytime observations reflect sea turtle movement, in or adjacent to the channels and in seagrass beds. G1 was very active at the jetty during daylight hours. Little or no movement was noted for any of the sea turtles monitored at night. L1, and G2 rested in seagrass beds and G1 was nestled very close to the jetty.

Seagrass beds typically border the navigable channels of the lower Laguna Madre. Sea turtles tracked in this study did not spend 100% of their time in the seagrass beds or at the jetties. The extent and duration of these excursions into the channel habitat is unknown at this time.

CONCLUSIONS

Sea turtles do frequent the dredged channels in the lower Laguna Madre, including but not limited to the intracoastal waterway and the Brownsville Ship Channel. During these times they are susceptible to dredging. Several other non-tagged sea turtles sighted in the channels would also be at risk to dredging.

This study has expanded our knowledge of sea turtle behavior and life history in and around passes and ship channels of the lower Laguna Madre. However, information needs to be collected on the depth partitioning of submerged sea turtles to see if they are spending their submerged time at the bottom or in the water column. Information on habitat utilization by these animals needs further detail to assess the full impact of hopper dredges on sea turtle populations in inshore areas.

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LITERATURE CITED

Dickerson, D. D. and D. A. Nelson 1990. "Proceedings of the National Workshop on Methods to Minimize Dredging Impacts on Sea Turtles, 11 and 12 May 1988, Jacksonville, Florida," Miscellaneous Paper EL-90-5, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

Doughty, R. 1984. Sea turtles in Texas: a forgotten commerce. Southwestern Historical Quarterly 88(1):43-69.

Francis, K. 1978. Kemp's ridley sea turtle conservation programs at South Padre Island, Texas and Rancho Nuevo, Tamaulipus, Mexico. Florida Marine Research Publications 33:51-51.

Landry, A. M. Jr., D. T. Costa, B. B. Williams and M. S. Coyne. 1992. Sea turtle capture and habitat characterization study. Unpublished report submitted to the National Marine Fisheries Service, 4700 Avenue U, Galveston, TX 77551. 109 p.

Manzella, S. A., J. A. Williams and C. W. Caillouet, Jr. 1990. Radio and sonic tracking of juvenile sea turtles in inshore waters of Louisiana and Texas. In: Richardson, T.H., J.I. Richardson and M. Donnelly (Compilers). 1990. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278, pp. 115-120.

Quammen, M. L. and C. P. Onuf. 1991. Laguna Madre: seagrass changes continue decades after salinity reduction. Unpublished report, National Wetlands Research Center, USFWL, Campus Box 339, 6300 Ocean Dr., Corpus Christi, TX 78412, 27 p.

Rabalais, S. C. and N. N. Rabalais 1980. The occurrence of sea turtles on the south Texas coast. Contributions in Marine Science 23:123-129.

Shaver, D. J. 1990a. Hypothermic stunning of sea turtles in Texas. Marine Turtle Newsletter 48:25-27.

Shaver, D. J. 1990b. Sea turtles in south Texas inshore waters. In: Richardson, T. H., J. I. Richardson, and M. Donnelly (Compilers). 1990. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278, pp. 131-132.

Williams, J. A. and S. A. Manzella 1990. Sea turtle sighting signs on the Texas Gulf coast. In: Richardson, T. H., J. I. Richardson and M. Donnelly (Compilers). 1990. Proceedings of the Tenth Annual Workshop on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFC-278, pp. 277-280.

Williams, J. A. and S. A. Manzella In press. Sea turtle sightings at passes on the Texas Gulf coast. In: Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation.

Table 1. Information on the capture/release dates and locations, measurements, flipper tags, and radio and sonic transmitters for five sea turtles (L=loggerhead, G=green) radio tracked near South Padre Island, Texas.

Turtle	Capture Date/Location	Release Date/Location	Measurements (cm)	Flipper Tag Numbers	Radio/Sonic Frequencies	Last Contact
L1	26 Jun 1991 Walt's Bar 26°05.04'N 97°13.79'W	28 Jun 1991 Walt's Bar 26°05.53'N 97°13.91'W	SL - 72.5 SW - 58.0 CL - 77.0 CW - 70.0	NNZ752 QQC705	164.099 Mhz 32.7 Khz	24 Sep 1991 Radio
G1	15 Jul 1991 North Jetty South Side 26°03.70'N 97°09.06'W	16 Jul 1991 North Jetty South Side 26°03.84'N 97°09.15'W	SL - 34.2 SW - 29.0 CL - 36.5 CW - 33.5	NNZ612 QQC707	164.929 Mhz 32.7 Khz	26 Oct 1991 Visual
G2	26 Jul 1991 Mexiquita Flats 26°02.40'N 97°11.59'W	28 Jul 1991 Mexiquita Flats 26°03.03'N 97°11.71'W	SL - 53.6 SW - 42.0 CL - 56.0 CW - 49.0	QQC708 QQC709	165.629 Mhz 37.0 Khz	24 Sep 1991 Sonic
G3	1 Aug 1991 Mexiquita Flats 26°03.09'N 97°11.30'W	2 Aug 1991 Mexiquita Flats 26°03.00'N 97°11.58'W	SL - 49.9 SW - 39.9 CL - 53.4 CW - 44.9	NNZ611 QQC710	165.586 Mhz 32.7 Khz	24 Sep 1991 Sonic
G4	1 Aug 1991 Mexiquita Flats 26°02.49'N 97°11.54'W	4 Aug 1991 Mexiquita Flats 26°02.94'N 97°11.63'W	SL - 54.1 SW - 42.2 CL - 57.0 CW - 49.4	NNZ753 QQC711	164.207 Mhz 40.0 Khz	16 Aug 1991 Visual

Table 2. Summary of mean submergence times by day and night for individual sea turtles.

Turtle	Mean Dive (min) Day	Night
L1	4.3	6.5
G1	3.5	25.6
G2	2.6	4.0
G3	2.4	---
G4	3.6	---

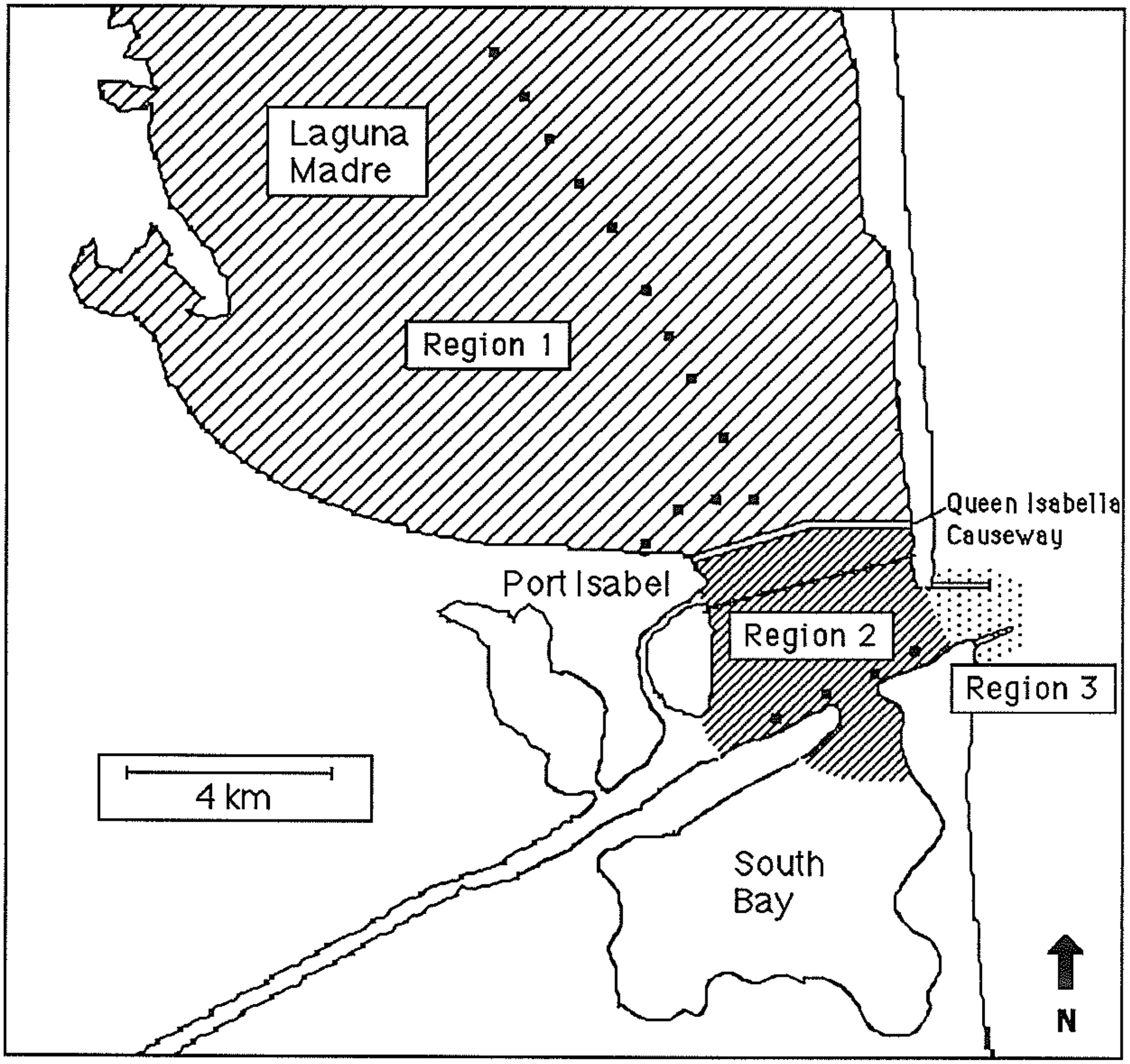

Figure 1. South Padre study area. Small squares represent the Intracoastal Waterway and Brownsville Ship Channel channel markers.

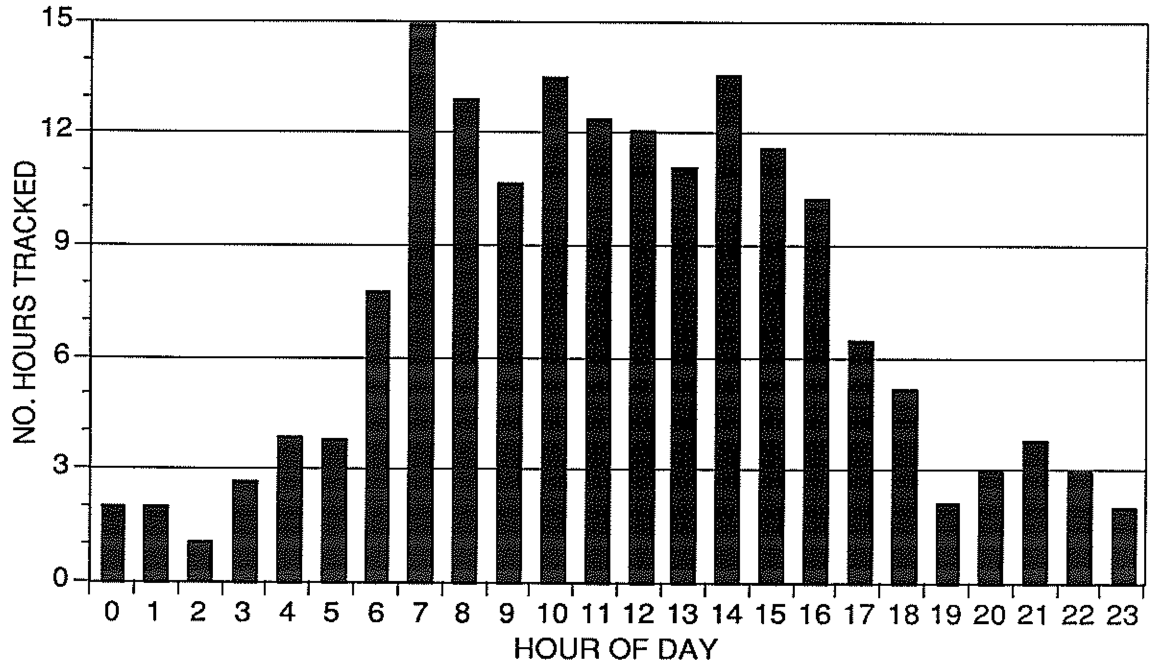

Figure 2a. Number of hours tracked by hour of day for L1.

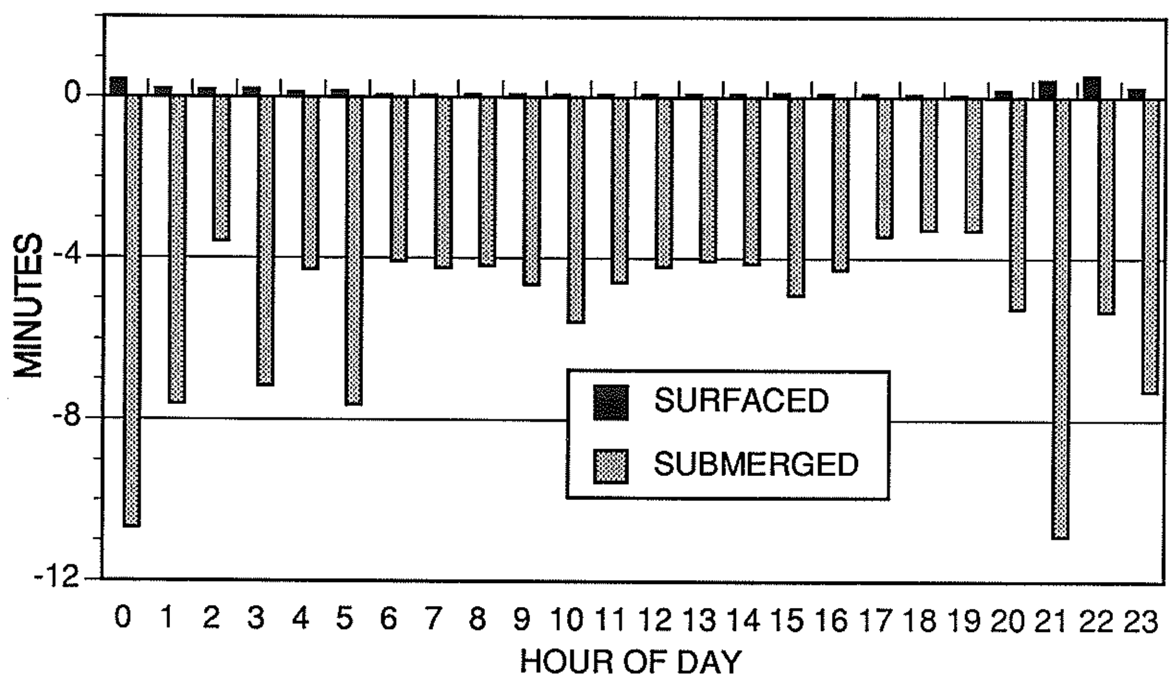

Figure 2b. Overall mean surface and submerged times by hour of day for L1. Surface times are slightly inflated due to the fact that turtles can swim near the surface with the antenna penetrating the air-water interphase, while they are still submerged. For the same reason, submerged times are slightly underestimated. Dives overlapping two 1-hour periods were placed in the hour block in which the dive began.

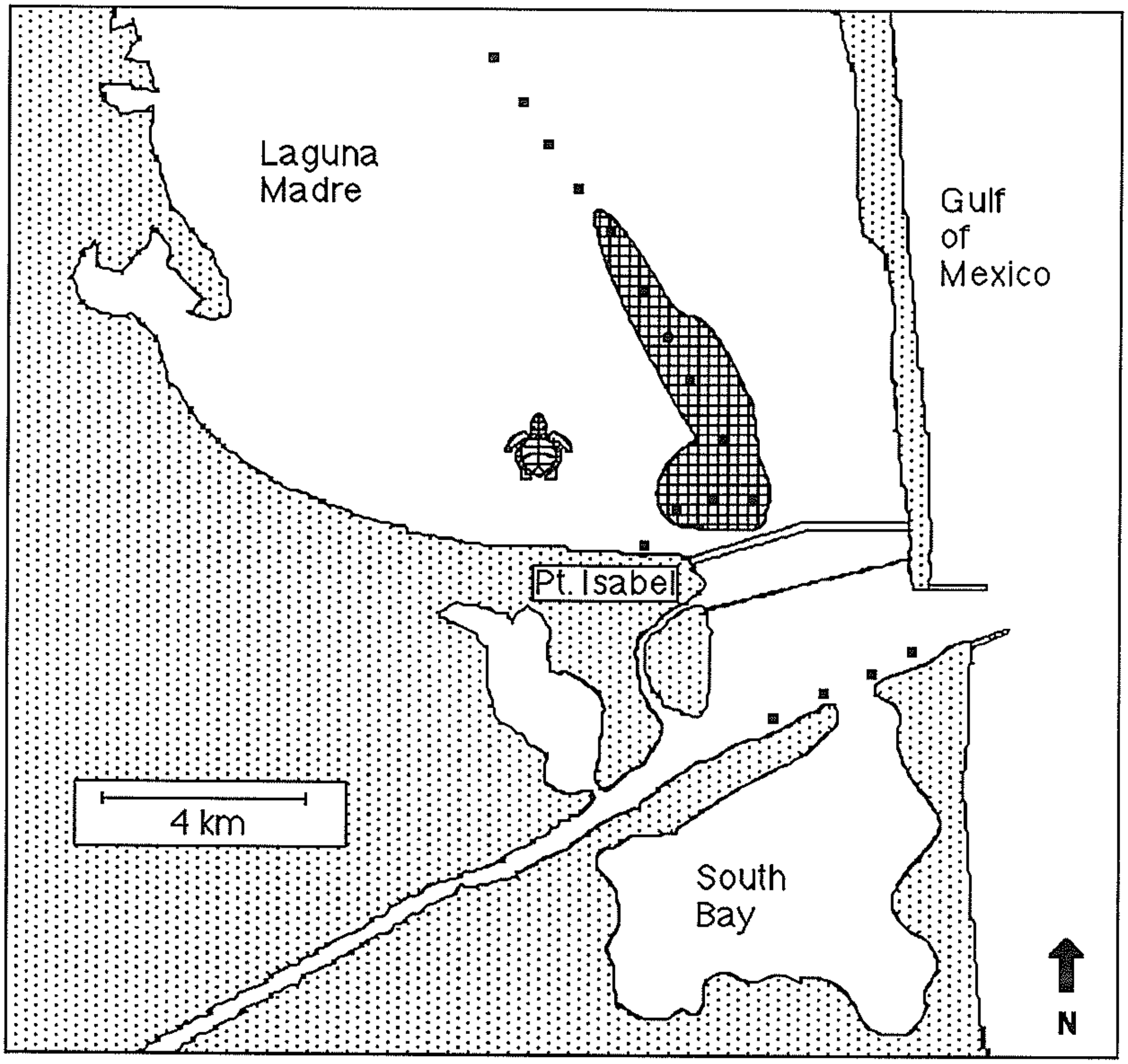

Figure 3. Movement of turtle L1 during the daytime (0630 - 2030) from 28 June - 20 August 1991. The capture and release site of L1 is indicated by a turtle replica on the map. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

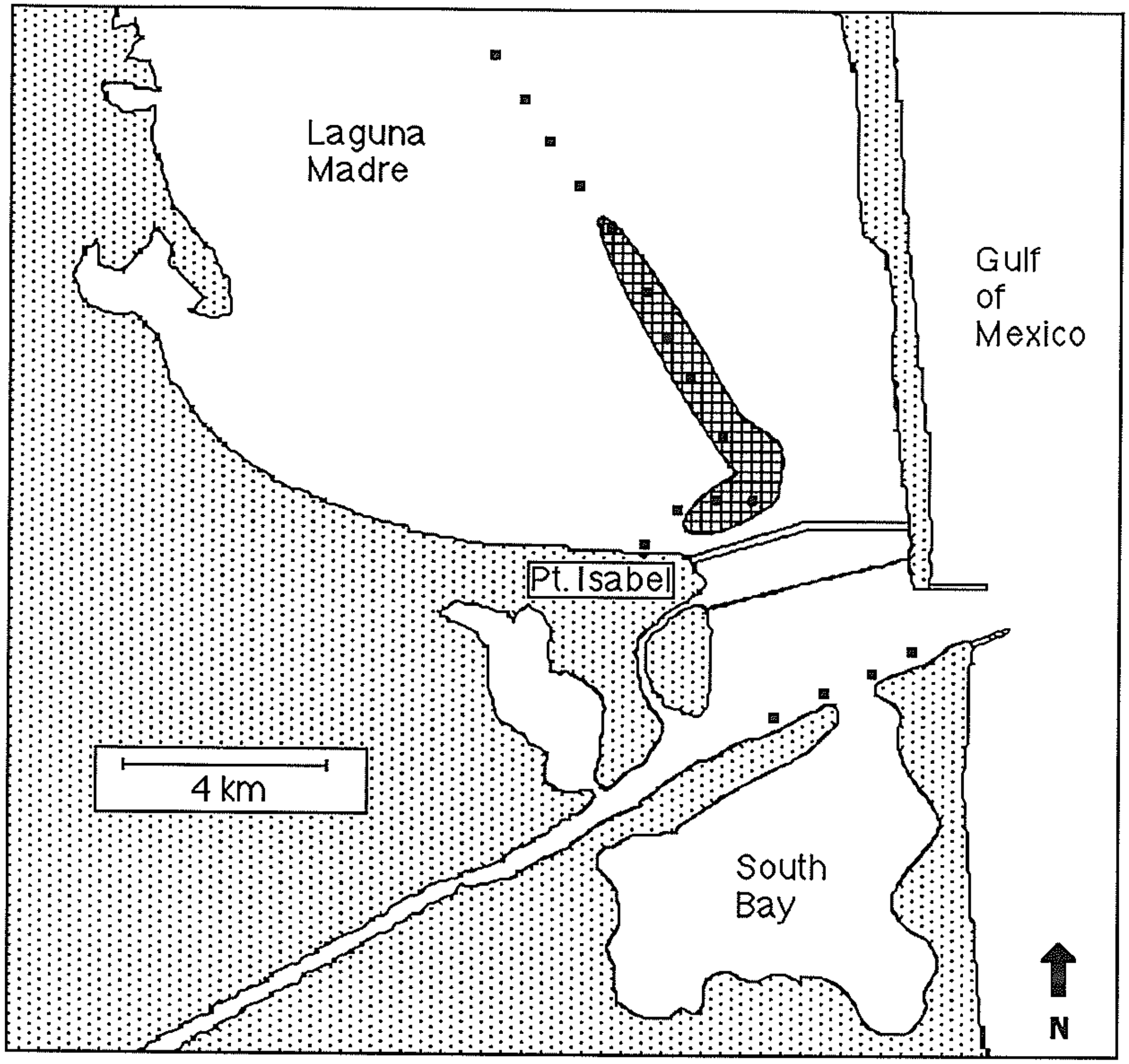

Figure 4. Movement of turtle L1 during the nighttime (2030 - 0630) from 28 June - 20 August 1991. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

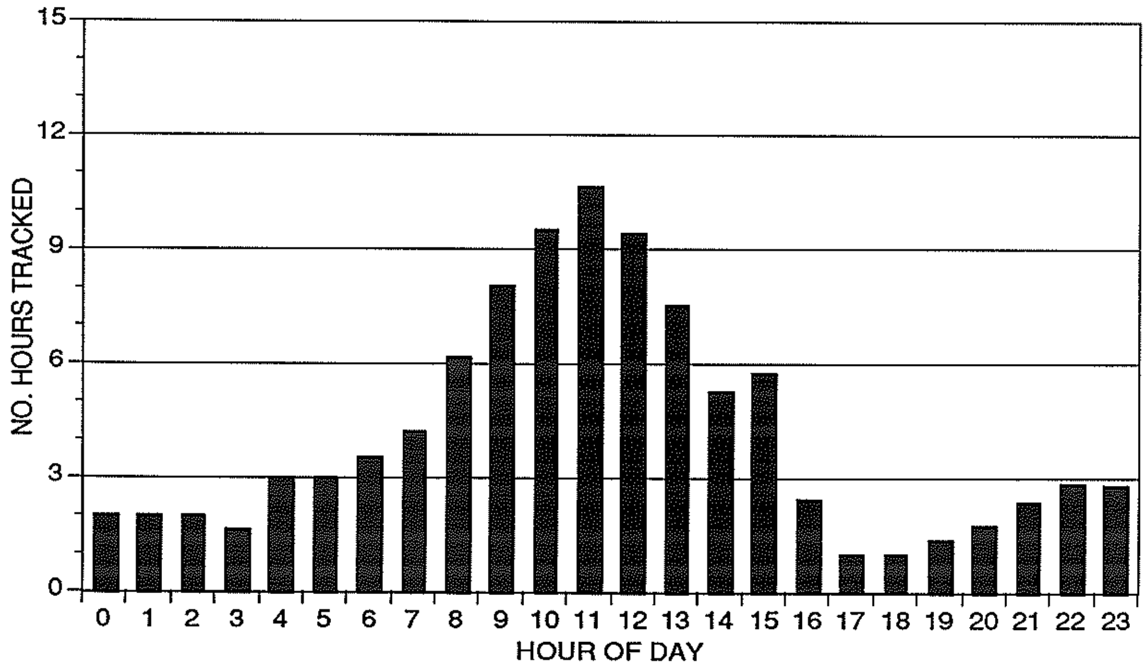

Figure 5a. Number of hours tracked by hour of day for G1.

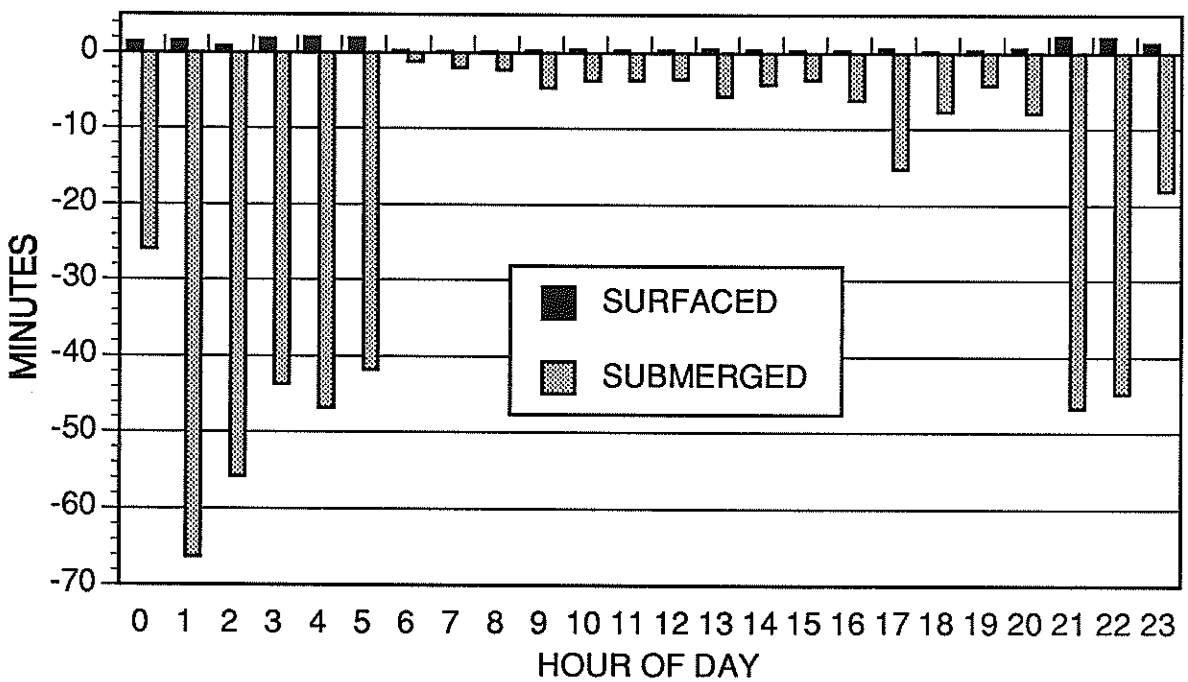

Figure 5b. Overall mean surface and submerged times by hour of day for G1. Surface times are slightly inflated due to the fact that turtles can swim near the surface with the antenna penetrating the air-water interphase, while they are still submerged. For the same reason, submerged times are slightly underestimated. Dives overlapping two 1-hour periods were placed in the hour block in which the dive began.

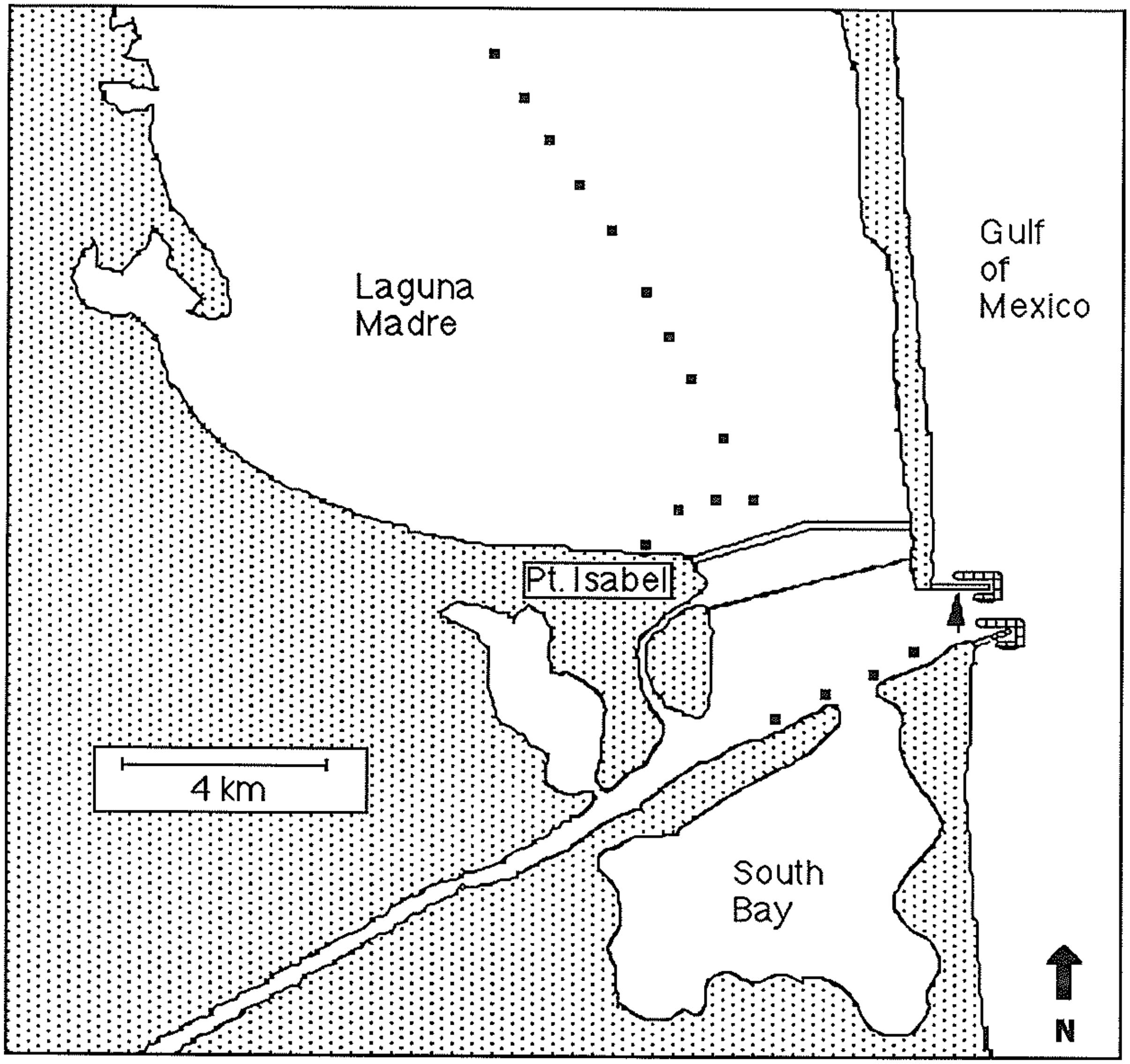

Figure 6. Movement of turtle G1 during the daytime (0630 - 2030) from 16 July - 18 August 1991. Arrow marks the capture and release site. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

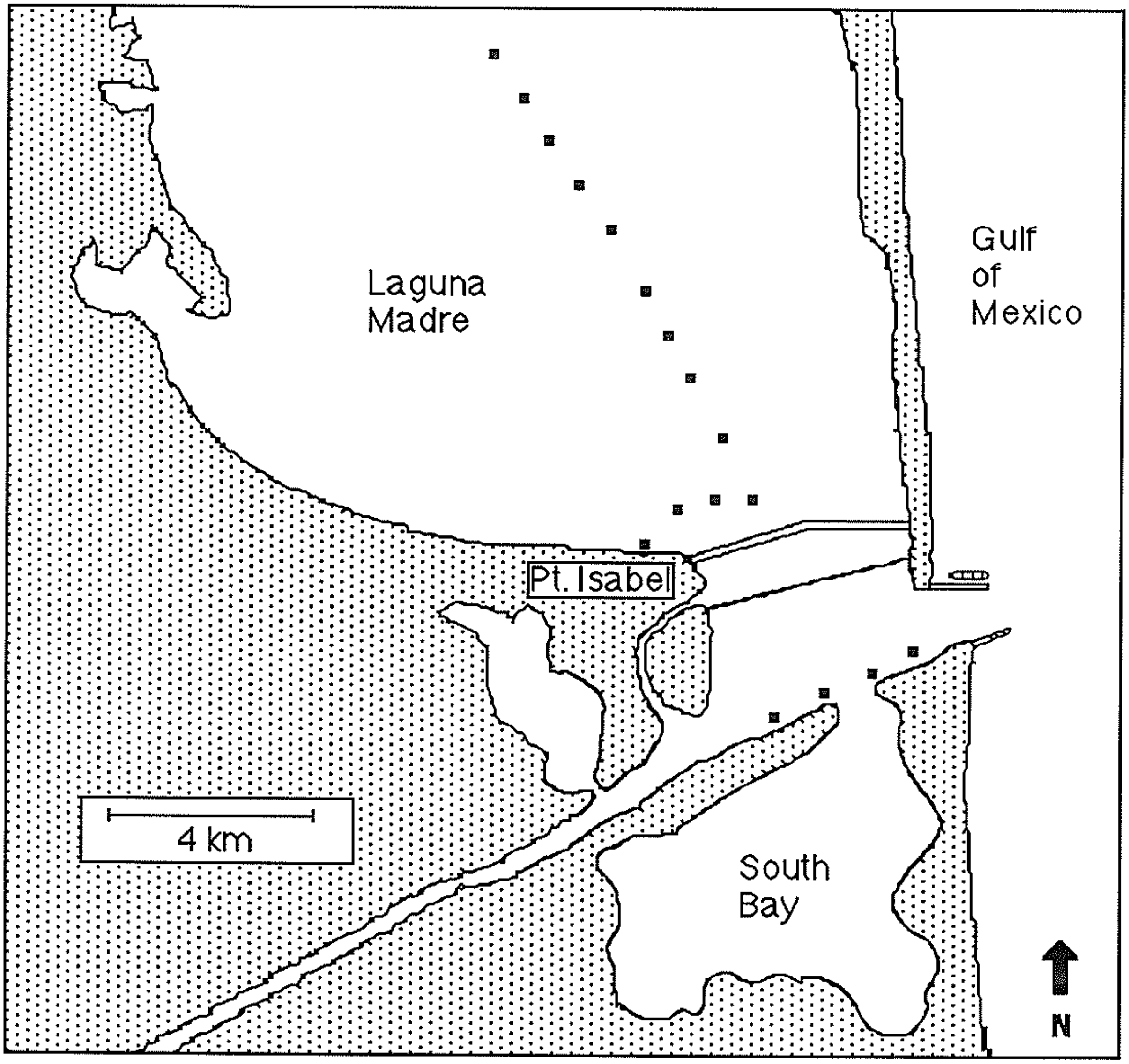

Figure 7. Movement of turtle G1 during the nighttime (2030 - 0630) from 16 July - 18 August 1991. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

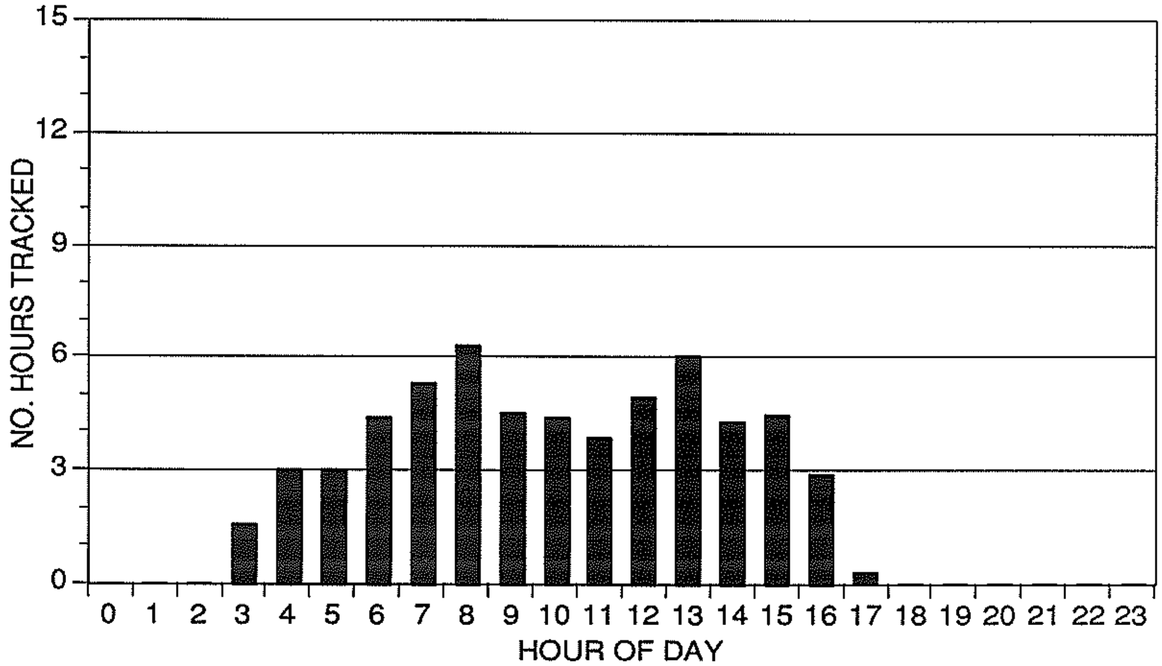

Figure 8a. Number of hours tracked by hour of day for G2.

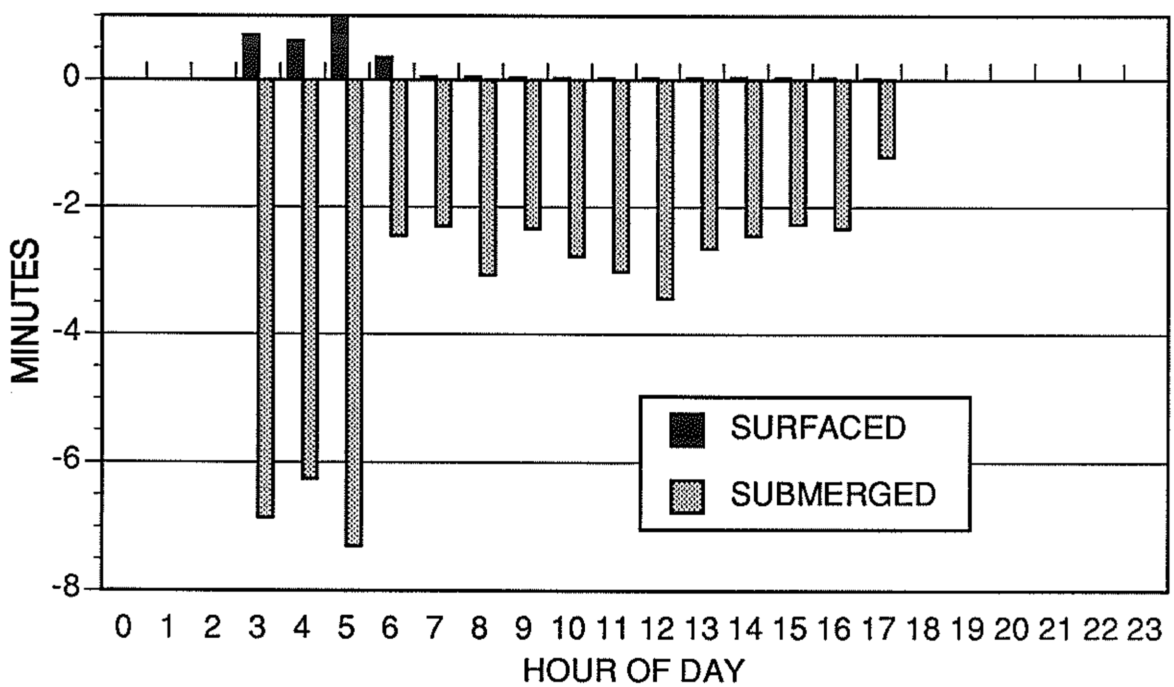

Figure 8b. Overall mean surface and submerged times by hour of day for G2. Surface times are slightly inflated due to the fact that turtles can swim near the surface with the antenna penetrating the air-water interphase while they are still submerged. For the same reason, submerged times are slightly underestimated. Dives overlapping two 1-hour time periods were placed in the hour block in which the dive began.

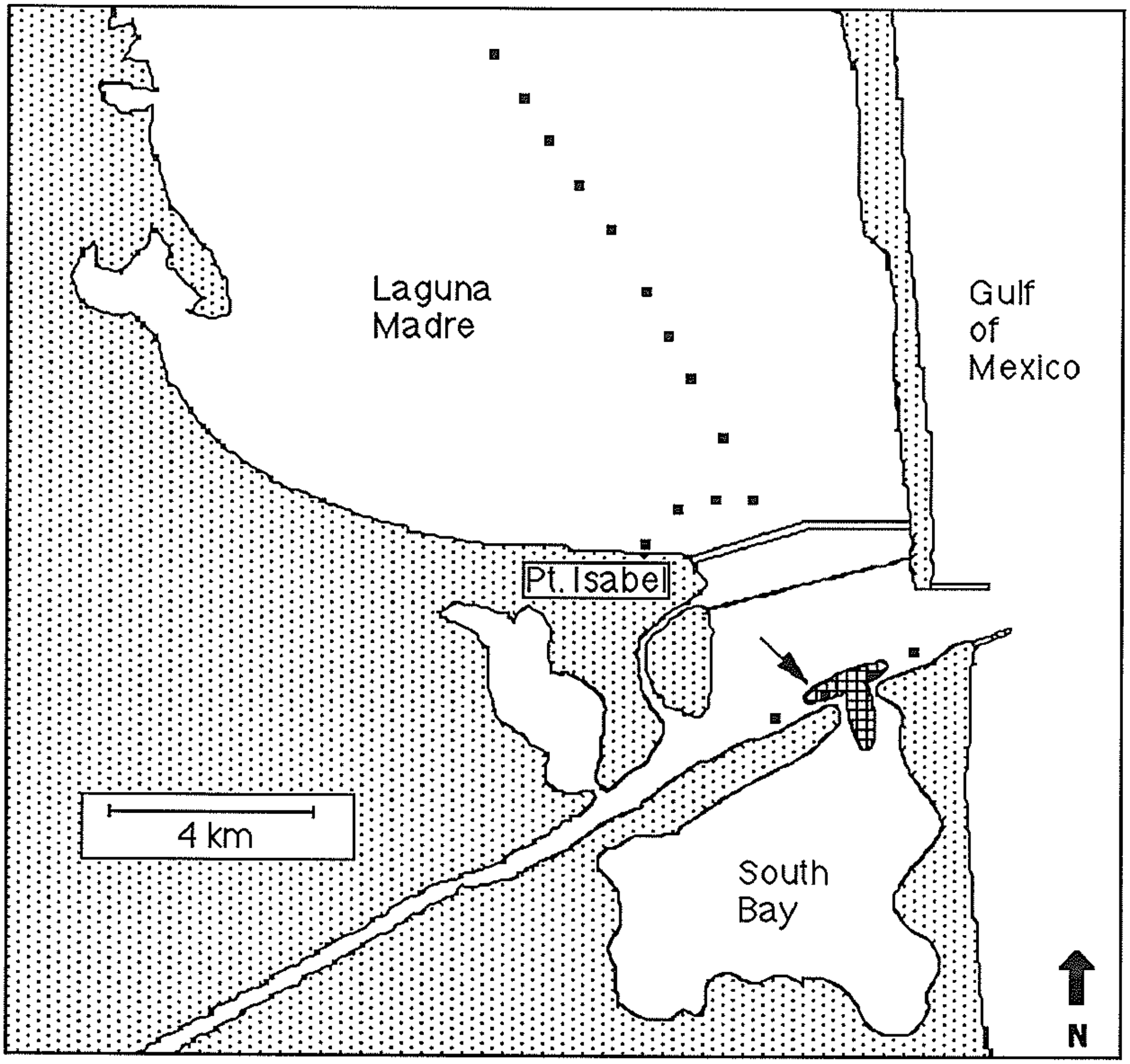

Figure 9. Movement of turtle G2 during the daytime (0630 - 2030) from 28 July - 22 August 1991. Arrow marks the capture and release site. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

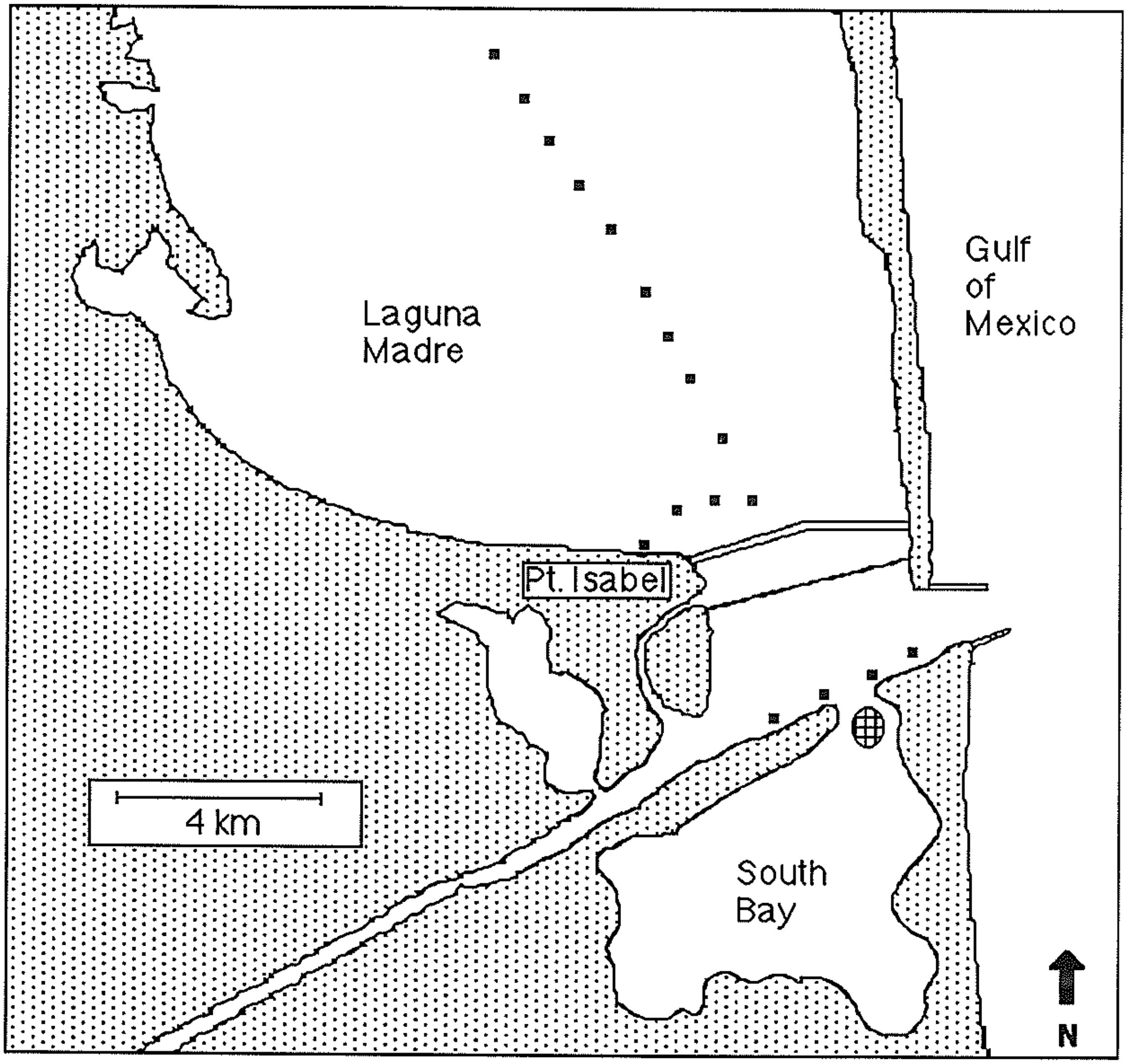

Figure 10. Movement of turtle G2 during the nighttime (2030 - 0630) from 28 July - 22 August 1991. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

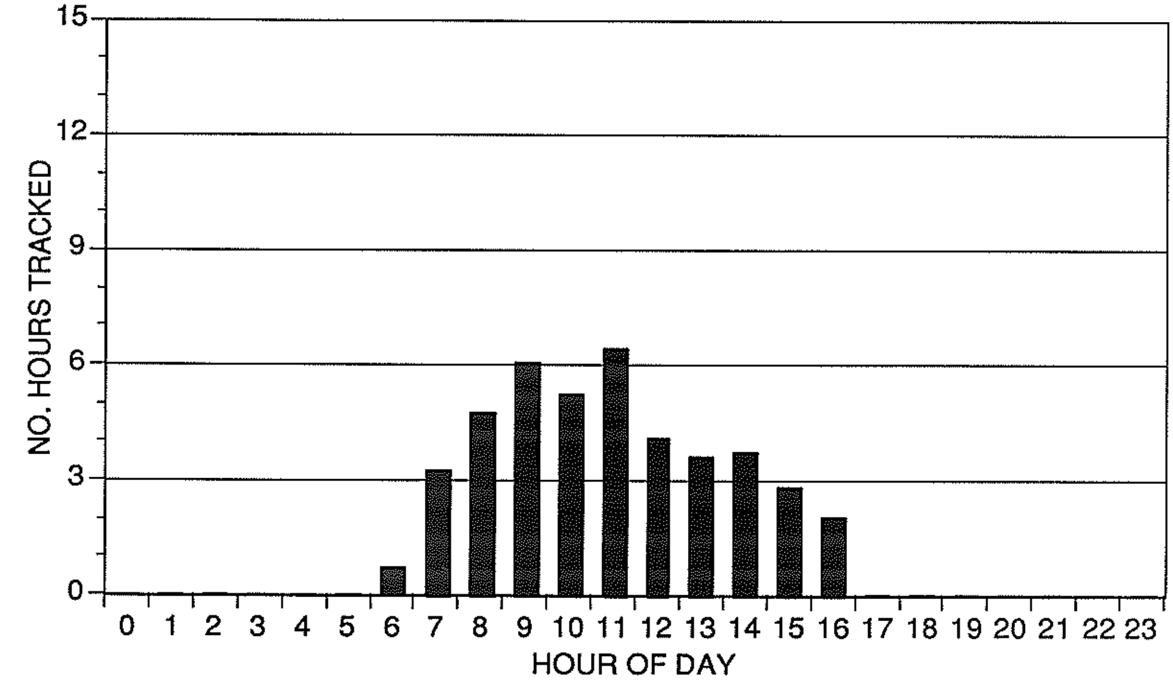

Figure 11a. Number of hours tracked by hour of day for G3.

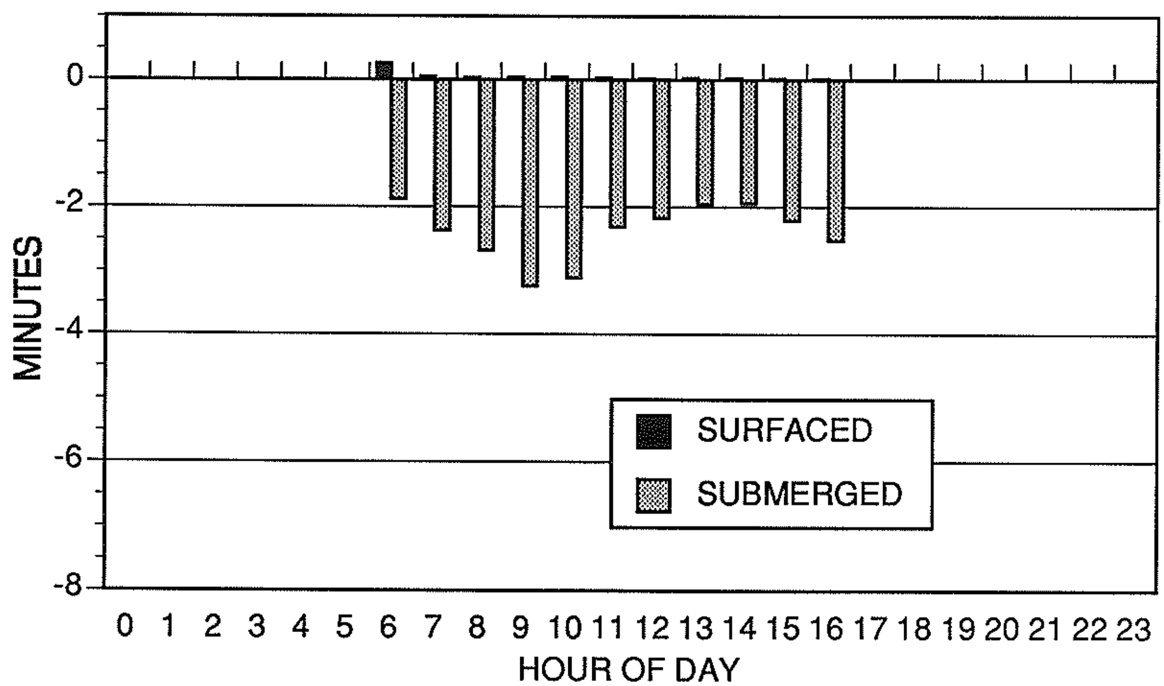

Figure 11b. Overall mean surface and submerged times by hour of day for G3. Surface times are slightly inflated due to the fact that turtles can swim near the surface with the antenna penetrating the air-water interphase while they are still submerged. For the same reason, submerged times are slightly underestimated. Dives overlapping two 1-hour periods were placed in the hour block in which the dive began.

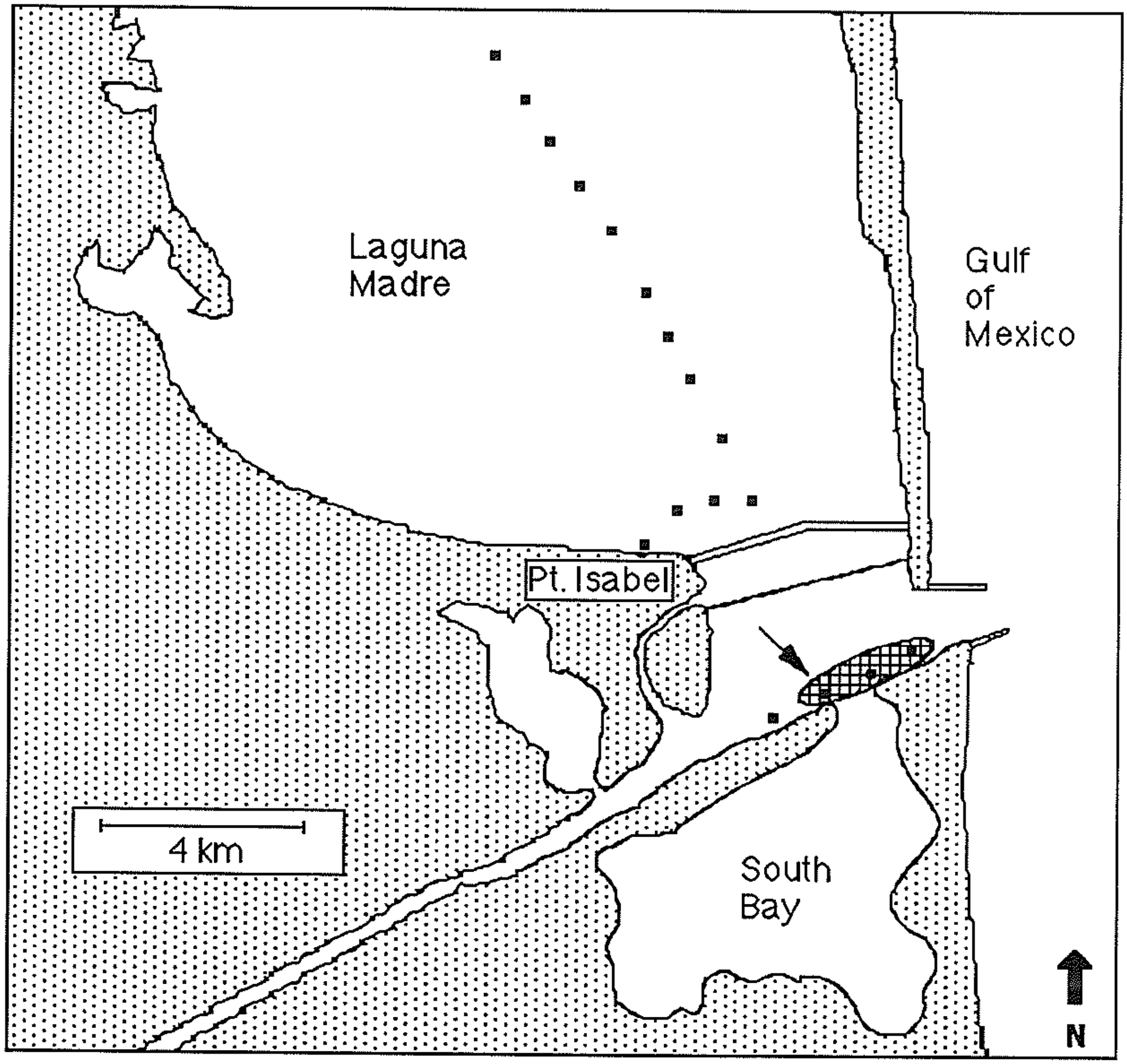

Figure 12. Movement of turtle G3 during the daytime (0630 - 2030) from 02 - 22 August 1991. Arrow marks the capture and release site. The cross-hatched area represents the geographic area in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

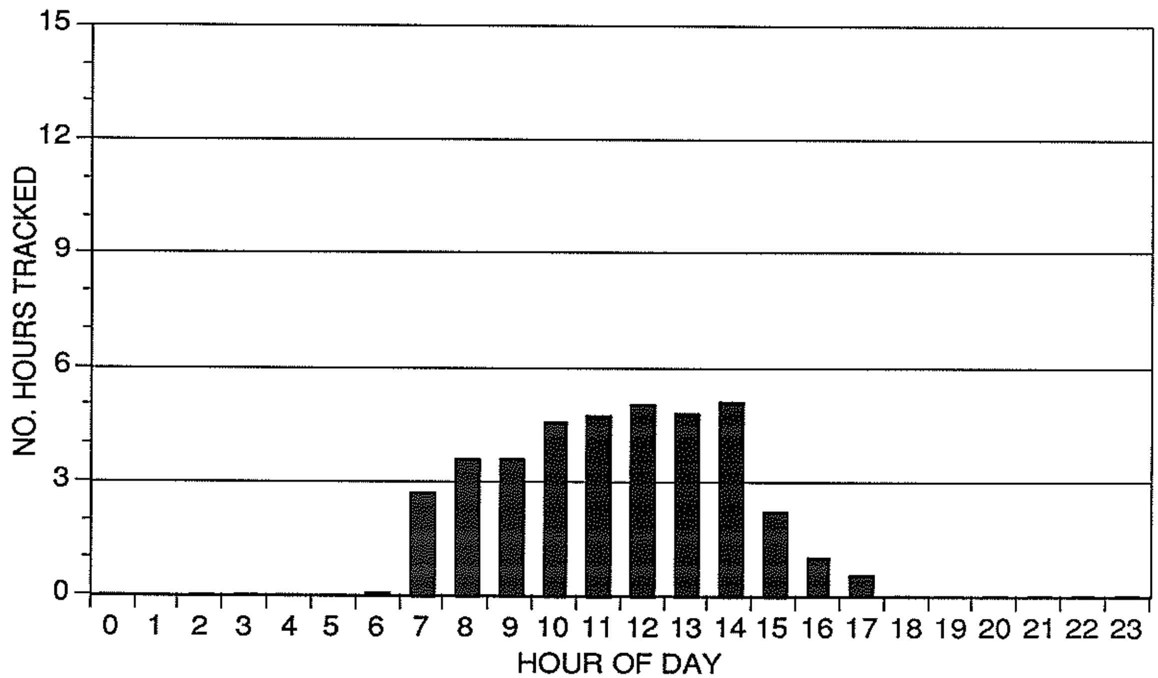

Figure 13a. Number of hours tracked by hour of day for G4.

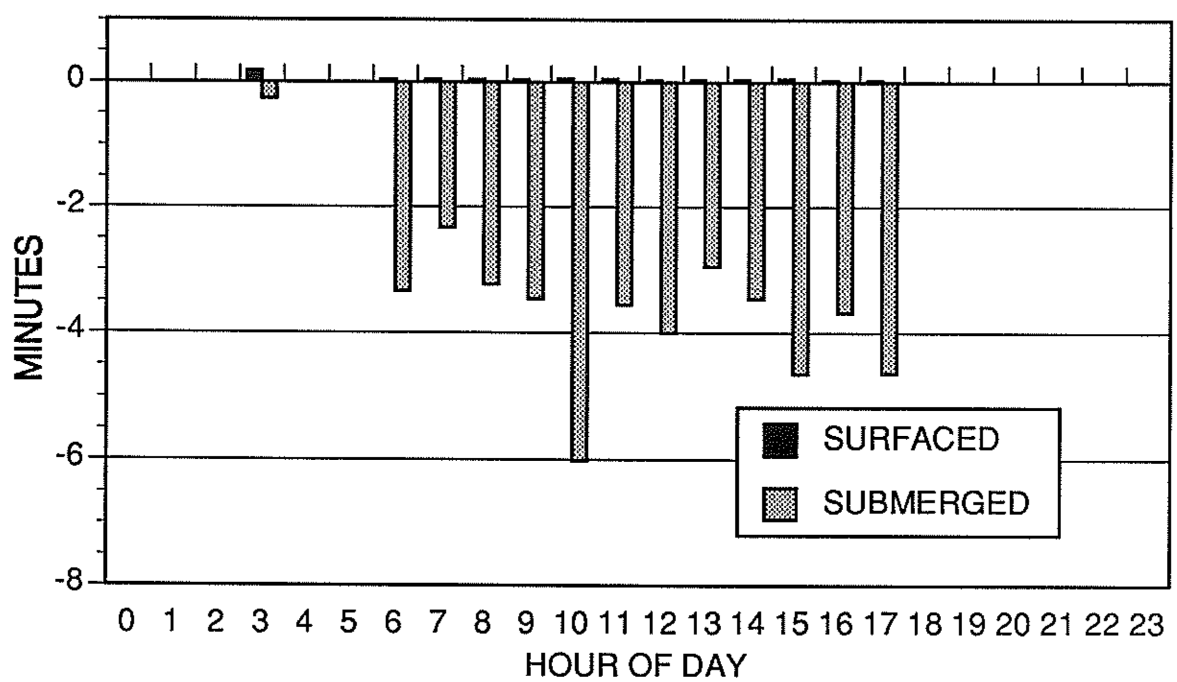

Figure 13b. Overall mean surface and submerged times by hour of day for G4. Surface times are slightly inflated due to the fact turtles can swim near the surface with the antenna penetrating the air-water interphase while they are still submerged. For the same reason, submerged times are slightly underestimated. Dives overlapping two 1-hour periods were placed in the hour block in which the dive began.

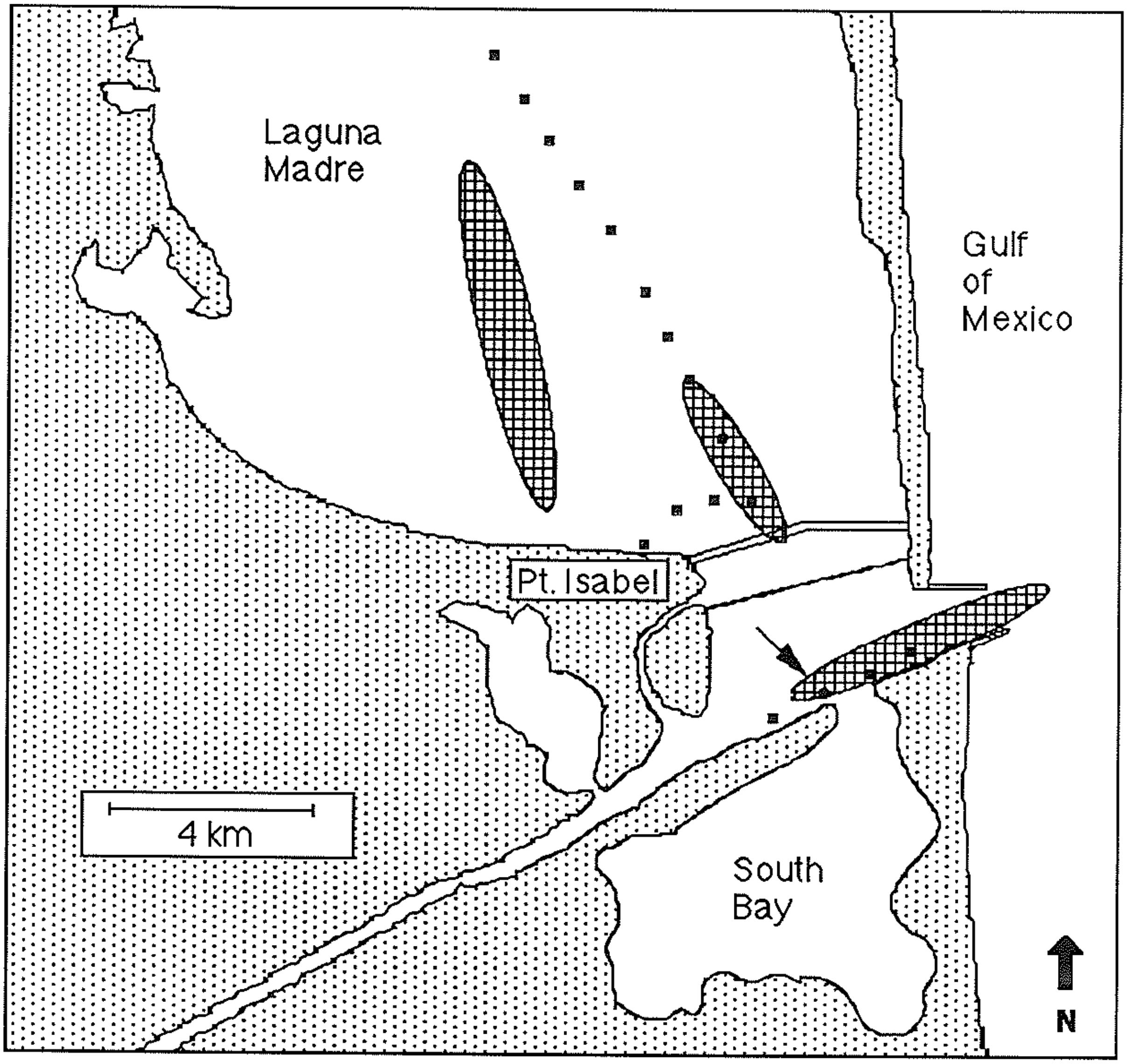

Figure 14. Movement of turtle G4 during the daytime (0630 - 2030) from 04 - 20 August 1991. Arrow marks the capture and release site. The cross-hatched areas represents the geographic areas in which 1) visual observations of the turtle were made or 2) strong reception of the sonic transmitter occurred.

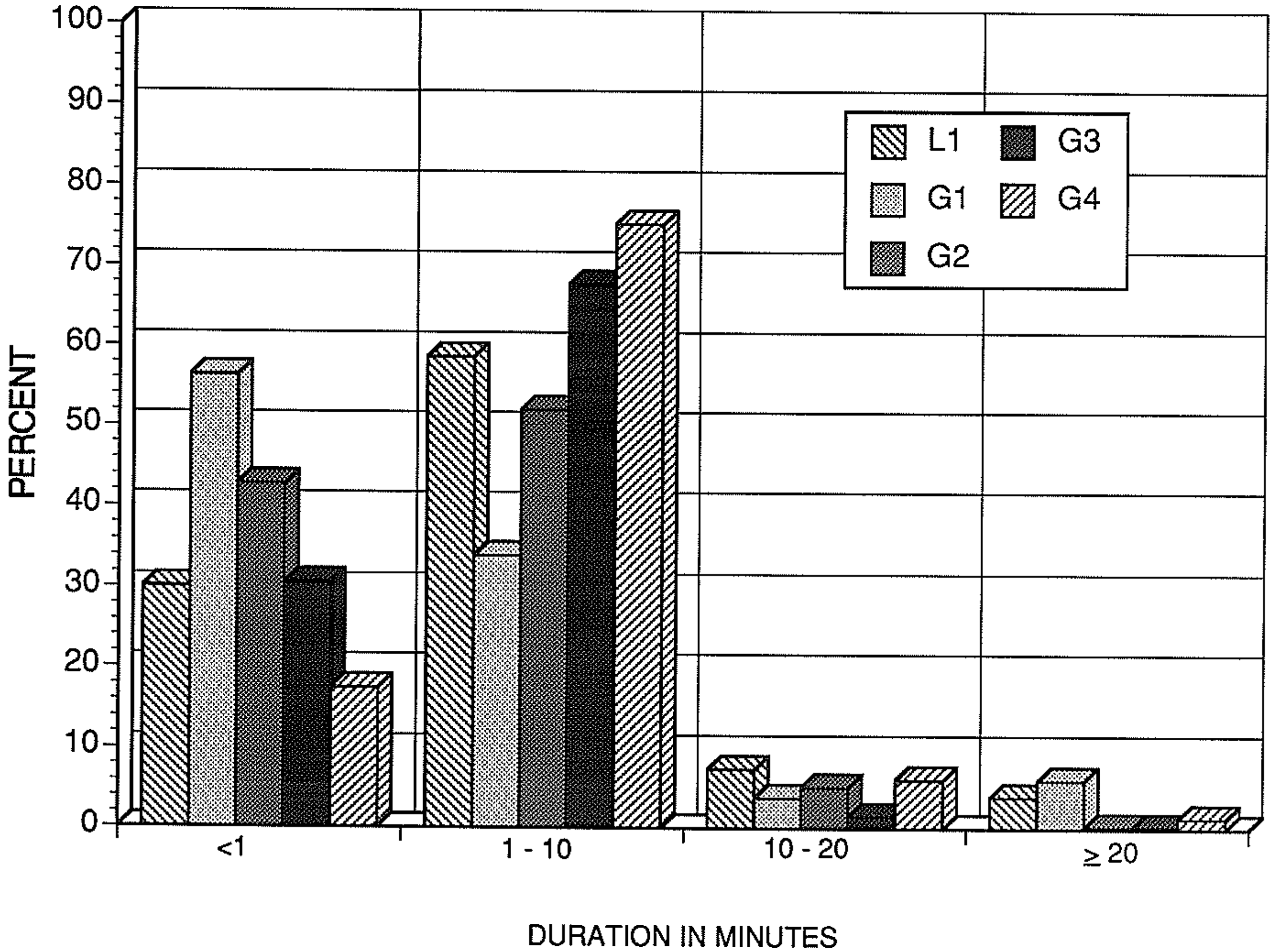

Figure 15. Turtle diving activity. Percent of dives during the day for each turtle are listed by time category: <1 min, 1-10 min, 10-20 min, and ≥ 20 min.

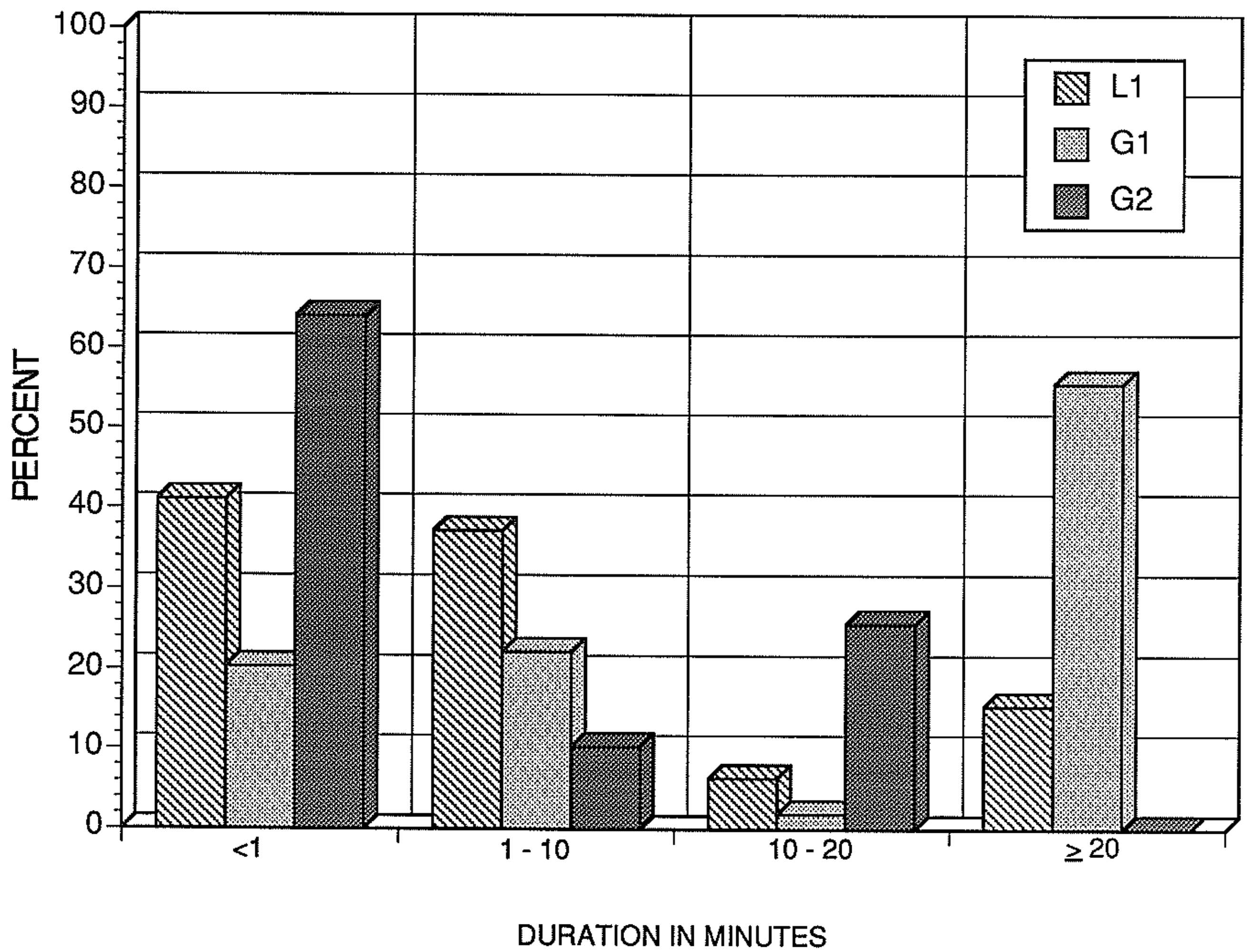

Figure 16. Turtle diving activity. Percent of dives during the night for each turtle are listed by time category: < 1 min, 1-10 min, 10-20 min, and ≥ 20 min.

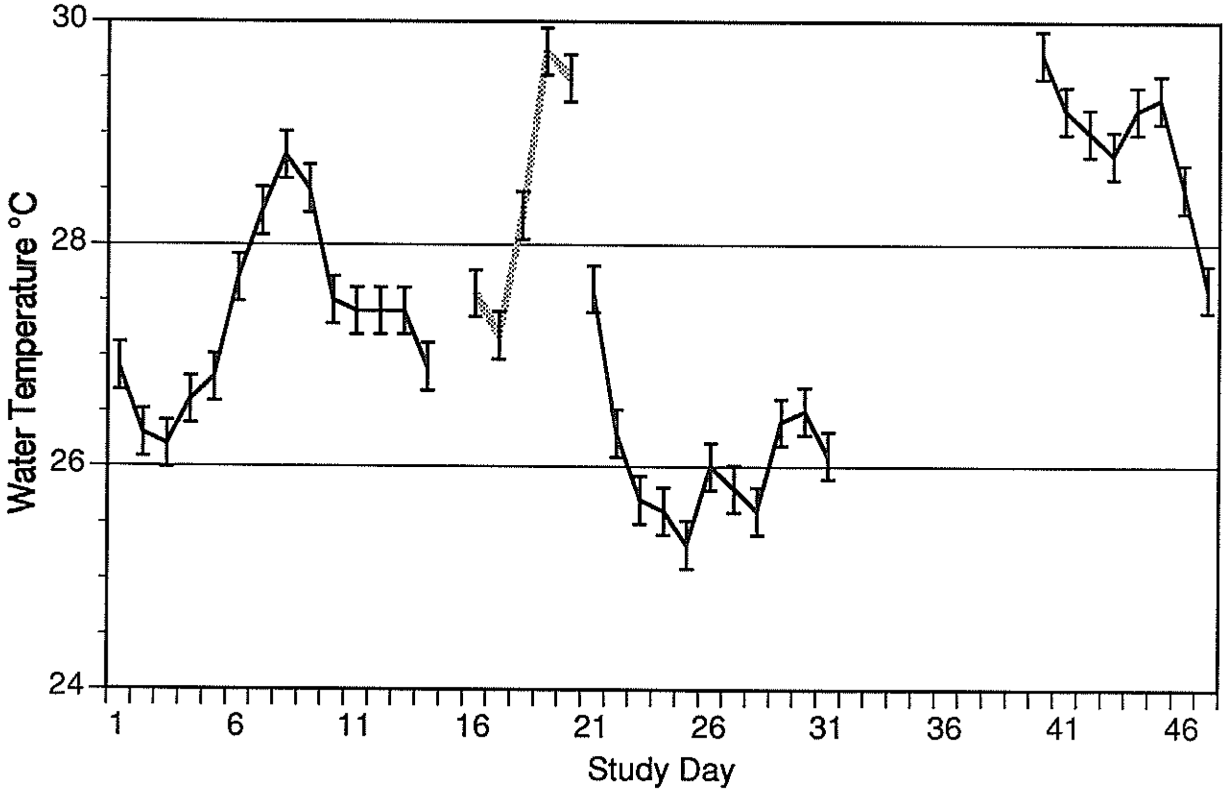

Figure 17. Means and standard errors of water temperatures (°C) by study day. Temperatures were recorded near the north jetty except for study days 16 - 20. On these days temperatures were recorded from the bay and are noted by the gray line. No data were collected on days 15, 32 - 39 and 48 - 58.

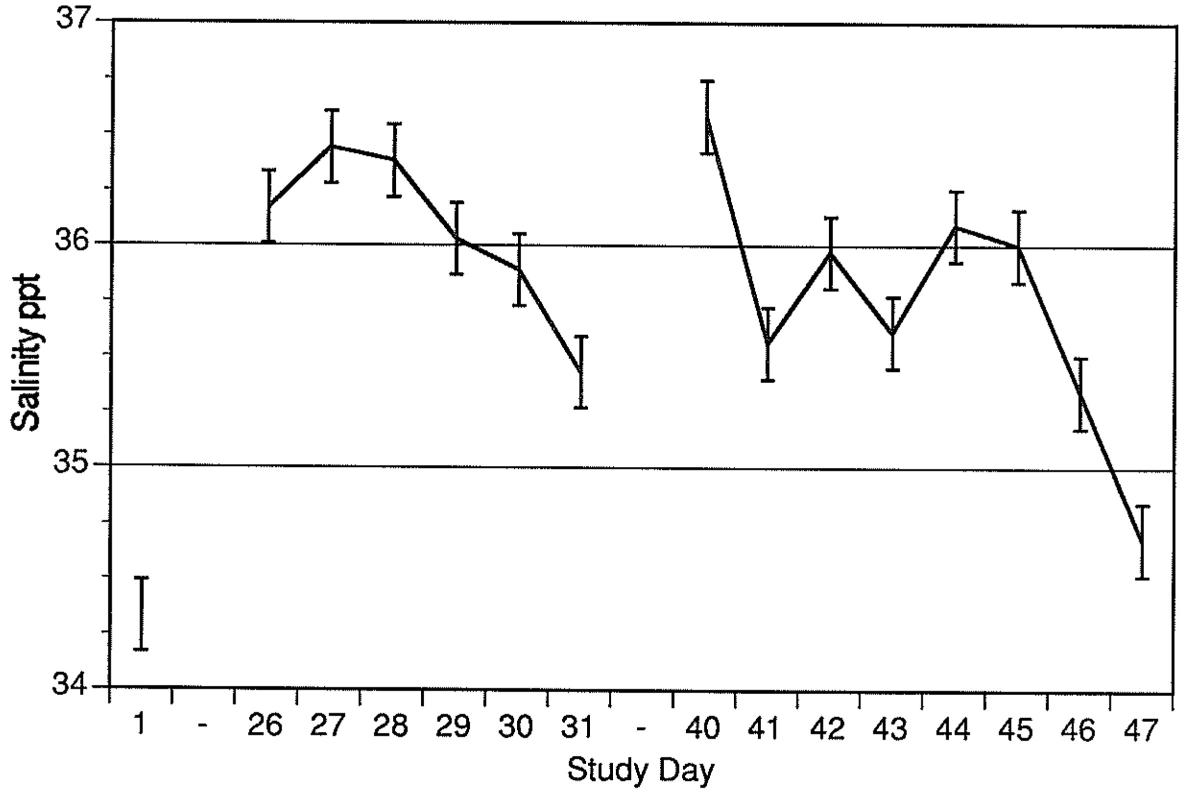

Figure 18. Means and standard errors of salinities (ppt) by study day. All salinities were recorded near the north jetty. No data were collected on study days 2 - 25, 32 - 39 and 48 - 58.

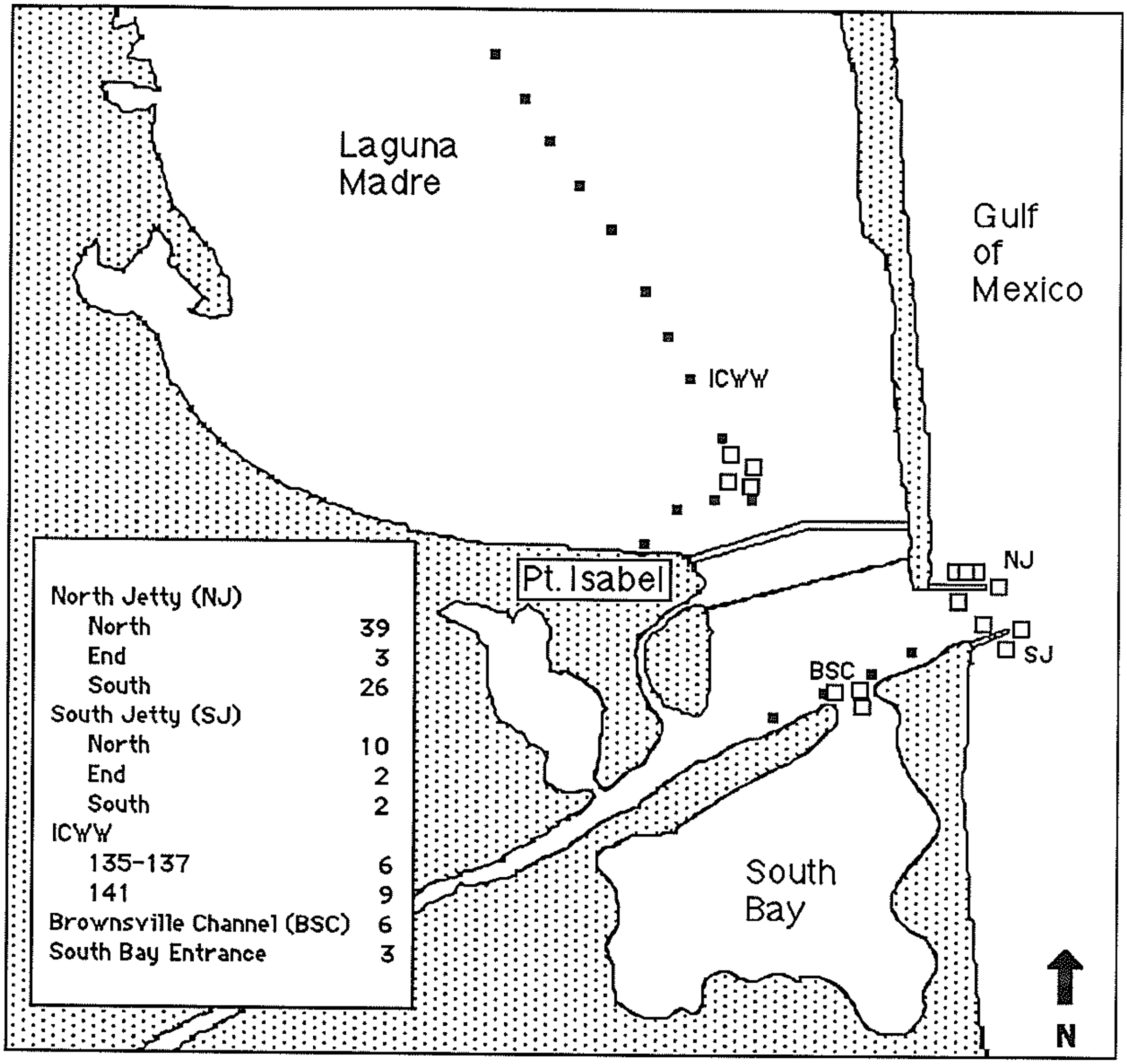

Figure 19. Non-radio tagged sea turtles seen from 28 June - 24 September. The open boxes indicate locations of sea turtles. The boxes may represent more than one sea turtle. The inset gives the numbers of sea turtles per location.